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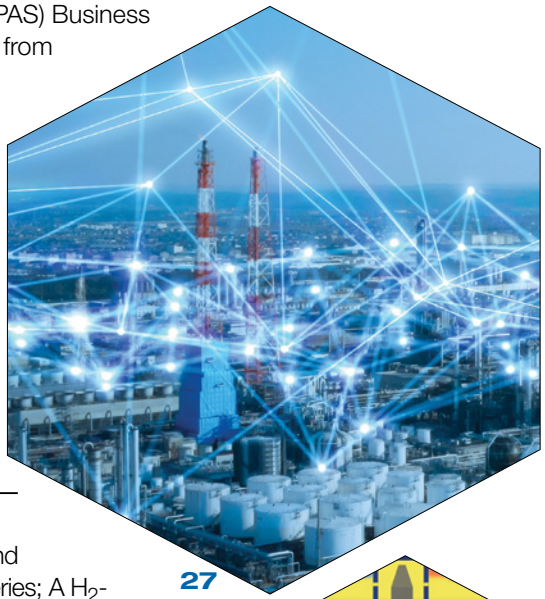

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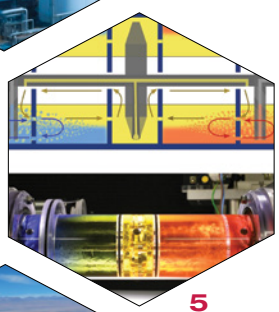

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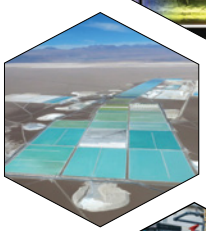

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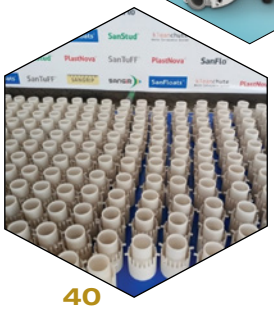

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Editor's Page

Choosing a career path

The past couple of months have been prime time for academic graduations. Graduation ceremonies, aptly named commencements, mark a time when graduates look forward to starting a new phase of their journeys. For some, it means moving on to a higher level of learning toward an advanced degree. For many, it means entering the working world, which poses a whole new set of decisions to be made about the variety of possible career paths that are open to chemical engineers. For me, that broad range of possible career paths is one of the reasons I pursued a chemical engineering education.

Wide breadth of possibilities

In addition to chemical manufacturing, the basic principles learned in the chemical engineering curriculum are applicable to jobs in energy, food-and-beverages, agriculture, electronics, personal-care products, mining, biotechnology, pharmaceuticals, biomedical work and more. With worldwide focus on environment and sustainability, many companies in the chemical process industries are pursuing sustainable manufacturing practices and decarbonization, and are developing technologies needed for the energy transition.

A report titled "New Directions for Chemical Engineering," published last year by the National Academies of Sciences, Engineering and Medicine (www.nationalacademies.org) outlines in detail, the many areas where chemical engineers are well-positioned to lead the way in many of the challenges we face today. Correspondences I have had with university professors and recent graduates indicate that today's graduates are very interested in sustainability, and those interests can align well with what companies are seeking (see for example the interests of the recent recipient of the Chopey Scholarship [*1*]).

Where to start

Along with the variety of subject areas that employ chemical engineers, within each of these fields there are typically jobs related to production, process development, research, safety, environmental regulations and more. Graduates looking for their first job are faced with a myriad of decisions to make. When I received my B.S.Ch.E., I was interested in research and development (R&D). I took a summer intern job in R&D, which helped confirm my resolve to pursue this area. I expected that a graduate level degree would be helpful, and so continued with further education before taking a "permanent" job.

In one of our published articles [*2*], a senior engineer shares his experiences and lessons-learned from his over 40-year career. Learning from this type of experience can be invaluable when defining your own career path. Additional references below [*3–5*] offer more insights in career development that may be helpful to those starting out and those facing "forks in the road" along the way. A career path, like life, is a journey. There is no right or wrong path — each person makes choices along the way. Take your time to make those choices, seek advice when you need it and create your own path. ■

Dorothy Lozowski, Editorial Director

1. Lozowski, D., WInner of the Chopey Scholarship, *Chem. Eng.*, p. 4, May 2023.
2. Rentschler, C., Career Guidelines for Young Engineers, *Chem. Eng.*, p. 56–59, January 2018.
3. Rentschler, C., Engineering Internships: A Win for Students and Companies, *Chem. Eng.*, pp. 66–68, May 2019.
4. Forsythe, G., Owning Your Career: Taking a Hard Look at 'Soft' Skills, *Chem. Eng.* pp. 41–44, July 2020.
5. Forsythe, G., Owning Your Career: Transitioning from a Technical Role, *Chem. Eng.* pp. 42–44, May 2023.

Edited by:
Gerald Ondrey

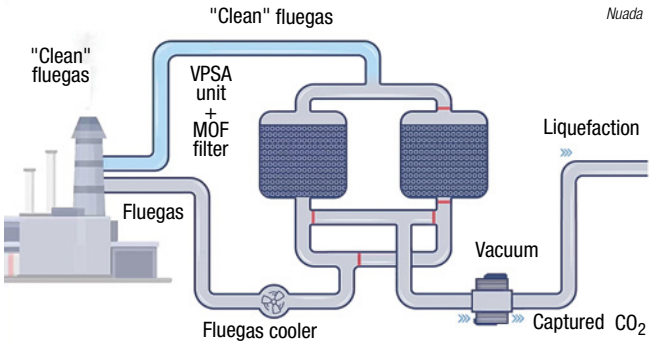
Pilot trials for a carbon-capture process that combines VPSA and MOFs

This summer, pilot trials will begin at a Buzzi Unicem S.p.A. (Casale Monferrato, Italy; www.buzziunicem.com) cement plant in Monselice, Italy, which will perform field tests of a new carbon-capture process developed by Nuada, the new tradename of MOF Technologies Ltd. (Belfast, Northern Ireland; www.nuadaco2.com). The pilot project is supported by the Global Cement and Concrete Assn. (GCCA; London, U.K.; www.gccassociation.org) and leading cement companies as part of GCCA's Innovandi "Open Challenge" (see *Chem. Eng.*, June 2022, p. 9) that targets "net zero" CO_2 emissions by 2050.

Nuada engineered a carbon-capture process that combines solid, metal-organic framework (MOF) adsorbents with proven vacuum-pressure-swing adsorption (VPSA) — a "heatless" and solvent-free process, explains business development manager Stratos Stavrakakis. "This represents a step change in innovation and yields an ultra-energy-efficient system that reduces the energy penalty by up to 80% compared to incumbent solutions," he says. In the process (diagram), cooled fluegas is passed through a packed-bed column where the CO_2 is selectively adsorbed at a slightly elevated ambient temperature and pressure. When the MOF filter is loaded, the fluegas is directed to another parallel bed, while the captured CO_2 is released under vacuum from the saturated bed. At bench scale, the process has been demonstrated to recover more than 90% CO_2 from fluegas, generating a CO_2-rich stream of 95+% purity.

Nuada manufactures its carbon-capture MOFs in house through a low-cost mechanochemical process, and "we can cover any requirements for replacing filters," Stavrakakis says. Extensive testing on the company's prototype has shown no degradation of the MOFs over two years, so the lifetime is believed to be much longer than this, he adds.

Nuada is also actively discussing demonstration opportunities with other sectors, such as steelmaking, waste-to-energy and "blue" hydrogen production, to verify the technology's in-field performance for treating various offgas streams, says Stavrakakis. The company is offering a tailored pilot program through "Nuada Scout." This service includes transport, installation, operation, testing and decommissioning of a pilot plant configured to site-specific fluegas, he explains. Nuada Scout provides a prefabricated containerized plant with core unit operations needed to evaluate carbon capture at 1 metric ton per day (m.t./d), with scope to bolt-on post-treatment packages for full carbon capture, utilization and storage (CCUS) assessments, Stavrakakis says.



Ligand-based separation method for rare earth elements

Rare-earth elements (REEs) are difficult to separate because of their similar properties, so conventional methods are often costly and generate significant amounts of waste. Researchers at Oak Ridge National Laboratory (ORNL; Oak Ridge, Tenn.; www.ornl.gov) have developed a new technique using two ligands with contrasting selectivities that suggests a path to more cost-effective and environmentally responsible separations.

The ORNL team reports a "tug-of-war" strategy that employs the natural separation of oil-water mixtures. The method uses a lipophilic ligand that has an affinity for heavier REEs, and a hydrophilic ligand with an affinity for lighter REEs. Specifically, a new, water-soluble bis-lactam-1,10-phenanthroline ligand with affinity for light lanthanides (from lanthanum to neodymium on the periodic table) is paired with an oil-soluble diglycoamide that selectively binds the heaviest lanthanides, such as holmium and lutetium. The two-ligand strategy "yields a quantitative separation of the lightest and heaviest lanthanides, enabling efficient separation of the neighboring lanthanides in between," (for example, from samarium to dysprosium), the ORNL researchers say.

"Our approach is flexible and can be tailored to select specific lanthanides for a faster route to separating adjacent elements," says ORNL scientist Santa Jansone-Popova.

USING WASTE HEAT

To convert large amounts of waste heat into electricity as efficiently as possible, turbines with a high degree of efficiency are required that work with a special conversion process — the organic Rankine cycle (ORC). In a pilot project for the development of such a turbine, the Center of Energy Technology (ZET) of the University of Bayreuth (www.uni-bayreuth.de) is cooperating with TGM Kanis Turbinen GmbH (Nuremberg, both Germany; www.tgmkanis.com). The Bavarian State Ministry of Economic Affairs, Regional Development and Energy is supporting the three-year, €1.7-million project.

Today, substantial heat generated by industrial production processes is still released into the environment, because the temperature is too low (typically between 100 and 500°C) for utilization. The waste heat can therefore only be con the help of the organic Rankine cycle (ORC), which uses an organic fluid with a low boiling point instead of water. In this way, turbines can be used efficiently to generate electricity even below 300°C.

In this project, the researchers will investigate an ORC using siloxanes as the working fluids, in combination with a test rig turbine (scalable up to 10 MW_{el}) to be installed at the site of TGM Kanis. The goal is to increase the isentropic efficiency of the ORC turbine compared to existing commercial products.

CAT SCREENING

When developing potential heterogeneous catalysts, determining

(Continues on p. 6)

the adsorption energy of molecules on surfaces is important for estimating catalyst performance. This is normally done using density functional theory (DFT). However, for large organic molecules, like those in plastics and biomass, this cannot be done.

To address this issue, scientists from the Institute of Chemical Research of Catalonia (ICIQ-CERCA) of the Barcelona Institute of Science and Technology (Tarragona, Spain; www.iciq.es), in collaboration with researchers from The Matter Lab at the University of Toronto, have created a new model called GAME-Net, a graph neural network (GNN) that rapidly evaluates adsorption energy when molecules attach to surfaces. On a laptop computer, GAME-Net can quickly make chemical predictions that would otherwise have to be simulated for days by DFT on a supercomputer.

Trained on a diverse dataset of small- and medium-sized molecules that containe functional groups, the GAME-Net model achieves a mean absolute error (MAE) of 0.17 eV on the test set and is six-orders-of-magnitude faster than DFT. When applied to biomass (wood) and plastic molecules with up to 30 atoms, the model predicts adsorption energies with a MAE of 0.016 eV/atom. The new tool is described in a recent issue of *Nature Computational Science*.

CELLULOSIC SUGAR

Toray Industries, Inc. (Tokyo; www.toray.com) and Mitsui DM Sugar Co., Ltd. (www.msdm-hd.com) have demonstrated a way to manufacture sugar derived from inedible biomass, such as bagasse (a pulpy residue from sugarcane processing),

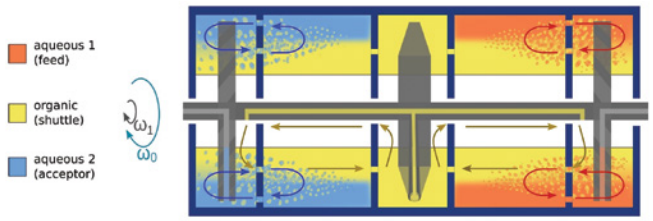
(Continues on p. 8)

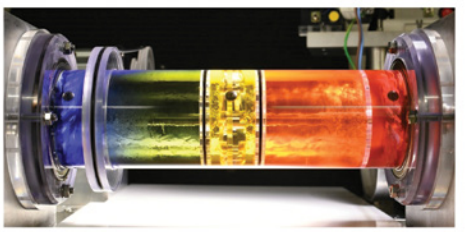
Spinning reactor recovers metals from spent Li-ion batteries

Recycling lithium batteries (LIBs) requires extensive use of hydrometallurgy, which requires multiple steps of extraction-stripping processes, each requiring separate reactors and different parameters. Although there have been attempts to devise a single-step, one-pot solution by partitioning the reactor using membranes, these efforts have failed in larger reactors, mostly due to membrane failures, especially under strong stirring.

To address this issue, an interdisciplinary research group, led by professor Bartosz A. Grzybowski at the Center of Soft and Living Matter within the Institute for Basic Science (IBS; Daejeon, South Korea; www.ibs.re.kr), reported a new method for recycling valuable metals such as lithium, nickel and cobalt, from spent lithium-ion batteries. Grzybowski's group has applied its spinning "concentric liquid reactors," to simplify the extraction-stripping process for LIB recycling. The study is described in a recent issue of *Advanced Materials*.

The horizontally rotating reactor (diagram), which was designed by co-author Olgierd Cybulski, can process complex metal mixtures in which aqueous feed, organic extractant and aqueous acceptor phases are all present in the same rotating vessel. Unlike the one-pot setups that use membranes, this reactor can be vigorously stirred and emulsified without the coalescence of aqueous layers. The arrangement of higher-pH "feed," organic extractant ("shuttle"), and lower-pH "acceptor" phases is maintained by placing all these liquids in a rotating vessel in a way that they form concentric layers stable enough to allow efficient interfacial mixing, but without coalescing the aqueous layers. "The technology is also forward-looking in the sense that, as we show, it is tunable to different "feed" metal compositions and of course, to metals other than those used in batteries," says Grzybowski.





Institute for Basic Science

A hydrogen-fired furnace for ceramics

This month, a demonstration experiment will begin on a new firing furnace for ceramics that is being developed by NGK Insulators, Ltd. (NGK; www.ngk.co.jp). The furnace is fired with hydrogen instead of fossil fuels, thereby reducing CO_2 emissions.

H_2-fired combustion furnaces for ceramics have not yet been put to practical use, but NGK has been conducting hydrogen flame-evaluation tests in a test furnace installed at its headquarters since January 2022. The company is striving for a firing furnace with high temperatures and excellent temperature uniformity. A new firing furnace (7-m wide, 2-m deep and 4-m high) developed by NGK will be installed at the hydrogen-combustion test field located at the Technical Research Institute (in Tokai City) of Toho Gas Co., Ltd. to develop a hydrogen regenerative burner for mass-production facilities. The regenerative burner performs both combustion and exhaust through internal ceramic heat storage. By alternating, at set intervals, between combustion and exhaust, the exhaust heat from the combustion gas is recovered through the heat storage and is reused to preheat the combustion air, resulting in high thermal efficiency. The new furnace is expected to save approximately 50% of energy requirements compared to conventional burners. The H_2-combustion field test will enable burner endurance measurements to be conducted at temperatures of 1,400–1,600°C — some of the highest temperatures used for firing of ceramics — and will enable the evaluation and verification of high-performance ceramic products fired for long periods of time.

With the new demonstration tests begun thin month, NGK aims to establish hydrogen-combustion technology for mass production by 2025, with the introduction to the domestic and overseas mass-production facilities from 2030. NGK aims to reduce CO_2 emissions by approximately 300,000 ton/yr and achieve net-zero CO_2 emissions by 2050.

and cassava pulp. These sugar monomers could be used for the production of biomass-based polymers for fibers, films, resins and more.

In the demonstration project, Toray leveraged a membrane-based bioprocess that combines enzymes and the company's water-treatment membranes to separate, purify, and concentrate cellulose-derived sugars in inedible biomass. Toray undertook this effort at a demonstration facility in Udon Thani Province, Thailand, of Cellulosic Biomass Technology Co., which Toray and Mitsui Sugar set up in January 2017. The demonstration is part of a project supported by the New Energy and Industrial Technology Development Organization. Toray showed that CO_2 emissions from this process are less than half those of conventional production setups that concentrate sugar solutions by evaporating water.

VOLCANIC FOOD?

As part of the ProFuture project (www.pro-future.eu), researchers at Wageningen University (the Netherlands; www.wur.nl) have developed a method to produce a promising microalga species that grows in volcanic hot springs. *Galdieria sulphuraria* is an extremophile microalga species with blue pigment that can live in extreme conditions and could represent a resilient source of protein for the future.

Although *G. sulphuraria* has been studied for decades due to its resilience and adaptability, it has not previously been examined as a possible food source or produced at scale. ProFuture studied a strain growing in the hot springs in the Naples region of Italy and found that *G. sulphuraria* biomass

(Continues on p. 9)

Recovering proteins — and more — from rapeseed

Last month, a pilot plant officially opened at the Fraunhofer Center for Chemical-Biotechnological Processes (CBP; Leuna, Germany; www.cbp.fraunhofer.de). The plant aims to further develop a process that recovers multiple products from rapeseed, including high-grade, pre-raffinate-quality rapeseed oil, a high-grade, protein-rich kernel concentrate, secondary plant substances and rapeseed hulls. The plant, which can process 50 kg/d of rapeseed, was built as part of the joint research project EthaNa, which has been funded by the German Federal Ministry of Food and Agriculture. The new facility consists of a de-hulling and an extraction plant.

A fluidized-bed system was developed that can continuously de-hull up to 100 kg/h of rapeseed. The separated hull fraction yields an additional product that can, for example, be used to manufacture bio-based insulating materials.

The de-hulled kernels are then processed by the patented EthaNa process, which uses a technique known as displacement extraction. The kernels are ground with an ethanol solvent at 70°C and the released oil droplets become emulsified in the ethanol phase. Secondary plant substances, such as sinapinic acid, tocopherols and polyphenols, are soluble in ethanol, and could be selectively extracted to recover bioactive compounds for cosmetics or pharmaceutical applications. The oil-rich liquid phase is separated from the protein-rich solid phase using a modified screw press or decanter. Finally, the emulsified oil is separated from the ethanol using a decanting tank. The recovered oil is almost entirely free from free-fatty acids and phosphatides, making it suitable for integrating directly into existing oil production lines for further processing.

The protein-rich rapeseed concentrate is said to be a significantly higher-grade product than the rapeseed meal from industrial oil mills, because it is free from hulls and secondary plant substances — only extremely small amounts of unwanted tannins and bitter substances remain.

Because of the mild processing conditions used, the recovered protein is not degraded, as occurs with the conventional hot-pressing process used in industrial oil mills. These water-soluble proteins can be extracted for use as alternative protein sources for the food industry. Further research work, for example on how the rapeseed proteins can be obtained to manufacture food, has already begun as part of a new E.U. project (see *Chem Eng.*, April 2023, pp. 12–16). The EthaNa process could potentially be used for processing other materials, such as sunflower and hemp seeds, beech nuts, or even coffee grounds.

Use existing refinery infrastructure for hydrogen storage and transport

Hydrogen is a clear piece of the decarbonization puzzle for many industrial sectors, including petroleum refining, but a major challenge lies in the storage and long-distance transport of hydrogen in its gaseous form. One proposed solution is the use of liquid organic hydrogen carrier (LOHC) technologies, wherein hydrogen is chemically combined into a liquid carrier for easier transport and storage, but LOHC requires reactors and other equipment that can be complex and expensive to set up. A new LOHC technology recently launched by Honeywell (www.honeywell.com), based on Honeywell UOP technologies, enables the use of existing infrastructure at petroleum refineries for LOHC, which significantly decreases the capital investment required to adopt LOHC processes when compared with constructing new facilities.

The new LOHC technology draws from established UOP technologies for aromatics saturation and naphtha reforming, both of which can achieve very high hydrogen selectivities, explains Kelly Seibert, vice president and general manager for Honeywell UOP Process Technologies for Refining and Petrochemicals. "The LOHC solution is based on the Honeywell UOP Toluene Hydrogenation process, in which toluene and clean hydrogen are reacted to form methylcyclohexane (MCH) in the presence of a proprietary catalyst. MCH can be transported using the same carrier vessels and infrastructure that are currently used to transport gasoline. At the import destination, the imported methylcyclohexane is dehydrogenated in the presence of a proprietary catalyst via the Honeywell UOP Methylcyclohexane Dehydrogenation process. High-purity hydrogen is released, which is then distributed to the hydrogen users, and the resultant toluene is ready for re-hydrogenation," says Seibert. According to Seibert, existing refinery processes, especially reforming units, can undergo minor revamps to be repurposed for LOHC, irrespective of the original licensor for the units.

World's largest double, re-slurry crystallization unit starts up in China

Last month, the world's largest double re-slurry *para*-xylene crystallization unit was started as part of Shenghong Refining and Chemicals Co. Ltd.'s integrated refining/chemicals project in Lianyungang, Jiangsu Province, China. Double re-slurry crystallization takes advantage of freezing-point differences among the three xylene isomers to separate and purify *para*-xylene. The unit, capable of producing 2.8 million metric tons per year of *para*-xylene, uses double re-slurry crystallization to separate *para*-xylene from a feed containing *ortho*- and *meta*-xylenes, as well as other aromatic compounds.

Crystallization technology for separating xylene isomers was originally developed by BP (now INEOS Aromatics) and competes with conventional separation technologies relying on selective adsorption and desorption. Over time, the technology has been refined and improved, with double re-slurry crystallization being first introduced to the marketplace in 2010. Lummus Technology LLC (Houston; Tex.; www.lummustechnology.com) is now the worldwide licensor for the technology.

The full *para*-xylene unit has an isomerization section, a fractionation section, and then the crystallization section with a recycle loop. The double re-slurry crystallization technology evolved from an original process with two refrigerated crystallization stages into a highly energy-efficient process that employs a refrigerated crystallization stage, followed by two re-slurry stages. With this arrangement, no additional refrigeration is required beyond the first stage. As Lummus Technology business development director Steven Cho explains, double re-slurry crystallization has several advantages over competing *para*-xylene purification approaches, including greater energy efficiency and lower emissions, because of crystallization's lower energy requirements in fractionation, and lower capital cost, because one of the crystallization stages is eliminated.

was found to have protein content in the range of 62 to 65%, which is relatively high compared to other algal and fungal microorganisms. *G. sulphuraria* proteins also contain all essential amino acids, and are rich in cysteine and methionine.

G. sulphuraria also contains a high concentration of a natural blue pigment commonly used as a colorant in cosmetics and food. The researchers developed a mixotrophic production process to increase the concentration of the blue pigment, and demonstrated the process in a 1,300-L pilot bioreactor at Wageningen University.

NEW FOODS

The University of Bath (U.K.; www.bath.ac.uk) will lead a new seven-year, £12-million ($15-million) project to develop new approaches to making food products. The Cellular Agriculture Manufacturing Hub is being funded by the Engineering and Physical Sciences Research Council, under its Manufacturing Research Hubs for a Sustainable Future initiative. The multidisci-

(Continues on p. 10)

plinary project also includes colleagues from the University of Birmingham, University of Aberystwyth, University College London, and the Royal Agricultural University, as well as industrial partners.

The project will explore the benefits that could arise from developing cell-level processes for producing foodstuffs and co-products. Benefits could include lower carbon emissions, less pressure on land use, reduced water consumption and more.

The initial focus will be the tissue-engineered cellular agriculture product, cultured meat, and the precision-fermentation product, alternative palm oil. ❐

Onsite bioelectrochemical treatment for ultra-concentrated wastewater

The combination of electrochemical principles and microbial activity is the backbone of a treatment technology designed specifically for ultra-concentrated and challenging industrial wastewater. The Bioelectrochemical Treatment Technology (BETT) developed by Aquacycl (Escondido, Calif.; www.aquacycl.com) involves "microbial fuel-cells" that produce direct electricity as they convert contaminants in the wastewater to CO_2 and water. "We use electrogenic microbial communities to treat highly concentrated wastewater, typically about 1,000 times more concentrated in organic carbon than what you see in a typical city sewer. We've created a unique place where these microbes can thrive within our reactors. They form biofilms on the anodes' surface in the reactors and use this surface to "respire," releasing electrons in the process. We capture those electrons in a circuit to produce power that is used to accelerate treatment rates," explains Sofia Babanova, CTO and co-founder of Aquacycl. The BETT process enables direct, onsite treatment in a modularized package, which is advantageous over other treatment methods for ultra-concentrated wastewater, which usually involve dilution or trucking offsite to a local utility or landfill. "Each of our reactors is about the size of a car battery, and we stack them together in hydraulic series. Right now, there's nothing else on the market that can treat those high-concentration streams onsite," adds Babanova.

Applications for BETT include sugary wastewaters with biological oxygen demand (BOD) in the 200,000 to 300,000 parts-per-million (ppm) range or wastewaters with biologically challenging compositions, such as pharmaceutical or petroleum products. The company has run demonstration-scale units for the U.S. Navy, a pig farm and a confectionary manufacturer, as well as a full-scale commercial system with PepsiCo. "With Pepsi, we showed that the installation could mitigate about 90% of greenhouse-gas emissions, because we're removing the high carbon load from their wastewater, and taking that load off the downstream utility," notes Babanova. Aquacycl is also partnering with tank terminal operator Royal Vopak (Rotterdam, the Netherlands; www.vopak.com) on using BETT for hydrocarbon remediation, treating toluene and benzene to meet permit compliance. Currently, the company is working with a greenfield distillery in Colorado to treat their wastewater for agricultural reuse. ■

Business News

Plant Watch

Trinseo inaugurates new PC dissolution pilot facility in the Netherlands

May 15, 2023 — Trinseo LLC (Berwyn, Pa.; www.trinseo.com) inaugurated its polycarbonate (PC) dissolution pilot facility in Terneuzen, the Netherlands. Dissolution recycling is a type of physical recycling process where the desired polymer is extracted by the use of solvents. The extracted polymers are then used to make new recycled polymers.

Air Products to significantly increase membrane production in St. Louis

May 15, 2023 — Air Products (Lehigh Valley, Pa.; www.airproducts.com) announced a $10-million project to significantly increase hollow-fiber membrane production at its St. Louis, Mo. facility. The project at the facility is driven by demand in biogas and hydrogen-recovery applications, as well as the use of nitrogen for the aerospace industry and dehydration-based products.

Dow selects Seadrift site for nuclear project

May 12, 2023 — Dow, Inc. (Midland, Mich.; www.dow.com) and X-Energy Reactor Co. (Rockville, Md; www.x-energy.com) announced that Dow has selected its Union Carbide Corp. (UCC) Seadrift Operations manufacturing site in Texas for its proposed advanced small modular reactor (SMR) nuclear project. Construction on the four-reactor project is expected to begin in 2026.

Entegris opens new manufacturing facility in Taiwan to support chipmaking sector

May 11, 2023 — Entegris, Inc. (Billerica, Mass.; www.entegris.com) has opened a new manufacturing facility located in Southern Taiwan's Kaohsiung Science Park. The company expects to invest a total of approximately $500 million in the plant, which significantly increases the company's production capabilities for advanced liquid filters, high-purity drums and advanced deposition materials for the chipmaking industry.

Fujifilm breaks ground on electronic-materials manufacturing site in Belgium

May 10, 2023 — Fujifilm Corp. (Tokyo; www.fujifilm.com) has broken ground on a new €30-million expansion at its electronic-materials manufacturing site in Belgium. The expansion will substantially increase the production capacity of Fujifilm Electronic Materials (Europe) N.V., which manufactures core components and chemicals required for semiconductor manufacturing, including cleaners, polyimides, developers and solvents. The expansion is targeted to be complete by the end of 2024.

Hexcel opens new composites plant in Morocco

May 10, 2023 — Hexcel Corp. (Stamford, Conn.; www.hexcel.com) has completed an expansion project at its engineered-core operations plant in Casablanca, Morocco to meet the growing demand for lightweight advanced composite materials for the aerospace industry. At the plant, which began production in 2018, Hexcel transforms lightweight honeycomb materials into engineered core parts that are used for structural reinforcement.

OQ Chemicals launches new pilot plant for customized esters in Germany

May 5, 2023 — OQ Chemicals GmbH (Monheim am Rhein, Germany; chemicals.oq.com) started up its new pilot plant for esters in Oberhausen, Germany. This test facility enables the company to manufacture small quantities of esters that are tailored for test purposes. The new products can later be produced on a large scale at OQ Chemicals' industrial plants.

Albemarle to double lithium hydroxide output in Australia

May 4, 2023 — Albemarle Corp. (Charlotte, N.C.; www.albemarle.com) plans to build two additional processing trains at its Kemerton lithium-hydroxide plant in Western Australia. The additional trains would increase the facility's lithium-hydroxide production by 50,000 metric tons per year (m.t./yr). Operating at full capacity, the Kemerton plant will produce up to 100,000 m.t./yr of lithium hydroxide. This investment, combined with the existing two trains at Kemerton operated by an Albemarle joint venture, would make Albemarle the largest producer of lithium in Australia.

Evonik begins construction of new alkoxides plant in Singapore

May 4, 2023 — Evonik Industries AG (Essen, Germany; www.evonik.com) started construction of a new production plant for alkoxides in Singapore. The company is expanding its production capabilities in response to growing demand for alkoxide catalysts, which are primarily used in biodiesel production and in synthesis applications in the pharmaceutical and agrochemical industries.

Nouryon to increase production capacity for organic peroxides in Ningbo

April 28, 2023 — Nouryon (Amsterdam, the Netherlands; www.nouryon.com) will invest in its facility in Ningbo, China to significantly increase the capacity of organic peroxide products. With this investment, Nouryon will double the annual production capacity to 6,000 m.t./yr each for Perkadox 14 and Trigonox 101 organic peroxides by mid-2024.

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Mergers & Acquisitions

Vopak agrees to divest its chemicals terminal in Savannah

May 16, 2023 — Royal Vopak N.V. (Rotterdam, the Netherlands; www.vopak.com) has agreed to sell its chemicals terminal in Savannah, Ga. to BWC Terminals, a U.S.-based bulk-liquids storage company. The operational capacity of the Vopak Terminal in Savannah is 250,566 m^3. This capacity is mainly used for the storage of vegetable oils, asphalt and specialty chemicals. The value of the transaction amounts to $106 million. The completion of this divestment is expected to be finalized during 2023.

Fujifilm to acquire high-purity chemicals business from Entegris

May 10, 2023 — Fujifilm has agreed to acquire CMC Materials KMG Corp. (KMG), a high-purity process chemicals (HPPC) business, from Entegris for $700 million. The acquisition will also provide Fujifilm with seven manufacturing locations across the U.S., Europe and Singapore, chiefly serving the electronics manufacturing sector.

TotalEnergies acquires Spanish plastics recycler Iber Resinas

May 9, 2023 — TotalEnergies SE (Paris, France; www.totalenergies.com) has acquired Spain-based Iber Resinas, a specialist in the mechanical recycling of plastics. Iber Resinas recycles plastics (polypropylene, polyethylene and polystyrene) derived from household and industrial waste in its two plants near Valencia, Spain. The company also has a network of customers to whom it sells its products for the manufacture of automotive parts, packaging and building materials.

Wacker acquires Spanish biotechnology firm ADL BioPharma

May 8, 2023 — Wacker Chemie AG (Munich, Germany; www.wacker.com) has acquired contract-manufacturing company (CMO) ADL BioPharma. In 2016, Wacker acquired from ADL BioPharma production assets located in León, Spain with a fermentation capacity of around 800 m^3. With this acquisition, Wacker now owns the entire plant, with total fermentation capacities of just under 3,000 m^3.

Kemira completes sale of colorants business

May 5, 2023 — Kemira Oyj (Helsinki, Finland; www.kemira.com) completed the divestment of most of its colorants business to ChromaScape. Scope of the transaction includes one Kemira manufacturing site in South Carolina. Kemira's colorants business includes basic and direct dyes, organic pigments and special colorants.

DuPont to acquire Spectrum Plastics Group

May 2, 2023 — DuPont (Wilmington, Del.) has agreed to acquire Atlanta-based Spectrum Plastics Group from AEA Investors. Spectrum is a leader in advanced manufacturing of specialty medical devices and components.

Suncor to acquire TotalEnergies EP Canada for around $4 billion

May 1, 2023 — Suncor Energy Inc. (Calgary, Alta. Canada; www.suncor.com) will acquire TotalEnergies EP Canada Ltd. from TotalEnergies for around $4.1 billion. ■

Mary Page Bailey

Lithium Extraction: Prime Time for Brine

Technologies to process lithium-containing brines are in high demand as manufacturers seek to improve recovery volumes and sustainability

The two main sources of lithium — one of the most in-demand materials on earth — are mining from ores and extracting from brines. An estimated 60 to 70% of global lithium reserves are found in the brines of South America's Lithium Triangle region, spanning the salars (salt plains) of Chile, Argentina and Bolivia (Figure 1). However, there is also promise in extracting lithium from geothermal brines and the wastewater of traditional mining sites. Although hard-rock mining has been a dominant technology, brine extraction is seen as having an overall smaller carbon footprint, especially with projects that can employ direct lithium extraction (DLE). While the majority of established projects in the salars evaporate the brine to recover its lithium content, DLE extracts lithium from the brine without significantly depleting the salar's brine volume.

Direct lithium production

In 2022, Energy Exploration Technologies Inc. (EnergyX; Austin, Tex.; www.energyx.com) became the first company to design, build and commission an in-field pilot plant in the Lithium Triangle. EnergyX has developed the LiTAS suite of processes for DLE and refining, which includes patented technologies for membrane extraction, solvent extraction and ion absorption. "Our overarching goal is DLE. No single technology is one-size-fits-all, so solutions are designed for each specific brine. It's a technology-agnostic, holistic approach," says Teague Egan, CEO of EnergyX. Not only does the company hold multiple patents at the materials level, covering membrane elements, ion-adsorption beads and solvents, it has also developed proprietary methods for interfacing the different unit operations, to optimize system integration to minimize water usage and maximize yield. Demonstrated lithium-recovery yields in LiTAS field tests were greater than 90%, compared with 30–40% for other brine processes. To design the optimal combination of technologies for a specific brine, there are several parameters that must be considered, including lithium concentration, the impurity profile, the ratio of impurities to lithium, the brine temperature and other inputs that may limit the process, such as regional water scarcity or the use of hydrochloric acid, sulfuric acid or soda ash, says Egan.

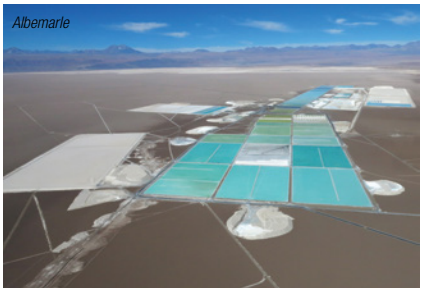


FIGURE 1. The salars of South America hold the vast majority of global lithium brines

"Our first pilot plant in the field has a capacity to produce three tons of lithium per year, with a 94% lithium recovery rate. Following this validation point, we are scaling up those systems to demonstration-scale test beds, which produce approximately 50 tons of lithium per year. That will be the last step before commercialization," says Egan. The larger demonstration plants are planned for Argentina, Chile, California, Utah and Arkansas. To bolster these commercialization efforts, GM Ventures is leading a $50-million Series B financing round for EnergyX.

The preferred form of lithium for battery production is lithium hydroxide monohydrate (LHM), so technologies that simplify the steps required to yield LHM are highly in demand. Typical conversion of lithium carbonate to LHM requires several stages that need significant water, energy and space. These processes can also produce large volumes of waste, and considerable lithium can be lost through co-precipitation with calcium carbonate, which can reduce lithium yield by as much as 20%.

IBC Advanced Technologies, Inc. (American Fork, Utah; www.ibcmrt.com) has developed a proprietary high-yield extraction process for converting brines to battery-grade end-products, Direct Lithium to Product (DLP; Figure 2). "The DLP process has demonstrated a 99% overall recovery rate of lithium from brine to production of over 99.5% pure LHM at large pilot scale. High extraction efficiency translates into less downstream processing volume per unit of brine treated and lower processing requirements due to the high purity of the extracted lithium," says Steven Izatt, president and CEO of IBC Advanced Technologies. Furthermore, he continues: "many process steps are thereby avoided, along with the consequent consumption of water, energy, reagents, equipment and the environmental deterioration that results from the need to separate impurity species."

A self-contained process, DLP's first step is selective extraction of lithium directly from brine using the company's automated Molecular Recognition Technology (MRT), which features proprietary SuperLig resin beads that are not only highly selective for lithium over other brine constituents, including magnesium, calcium, sodium, potassium and boron, but are also designed with rapid bind-

FIGURE 2. The direct production of battery-grade lithium from brines has been demonstrated with 99% overall recovery rate

and-release kinetics. Expeditious elution of the lithium from the resin results in a pure lithium eluate. Notably, no pre-extraction steps are required, and the post-processed brine can be returned to the salar. "Because the extraction yield is so high, a smaller volume of brine is treated per unit of lithium extracted. The lithium-rich solution from the MRT unit is transformed directly and crystallized to pure LHM," explains Izatt. Chilean mining company Simco Lithium is currently planning a commercial-scale implementation of the DLP process in Salar de Maricunga, Chile. There are also several more pilot and laboratory tests underway at other locations. "A wide range of brines has been successfully tested, including those containing very high levels of impurities in the tens of thousands of milligrams per liter range," adds Izatt.

Making mining more responsible

To help mine operators improve their environmental and social performance, the Initiative for Responsible Mining Assurance (IRMA; Seattle, Wash.; www.responsiblemining.net) has set forth a third-party voluntary assessment system consisting of 400 standards spanning 26 comprehensive topic areas to drive ongoing efforts to improve mining operations.

Albemarle Corp. (Charlotte, N.C.; www.albemarle.com) is among the companies participating in IRMA audits at several global sites, and was the first lithium company globally to undergo a third-party audit at its lithium operations at the Salar de Atacama in Chile (shown in Figure 1). For the company's operations at the salar, a goal of achieving IRMA 50 — meaning that 50% of the 400 standards are met — has been set for the end of 2023. "It's been quite a process to get ready for IRMA 50 and engage in the audit process, as well as continuing to work toward having the IRMA report published. We've had to study all the standards and figure out where we have gaps. About 40% of the standards deal with community engagement, so we now have an agreement with the indigenous community at the salar where we work together on environmental monitoring and share a percentage of sales," says Ellen Lenny-Pessagno, global vice president for external affairs and sustainability for Albemarle's Energy Storage business unit. "Becoming IRMA compliant isn't a one-time look at the way a site operates. It is a continuous process," emphasizes Lenny-Pessagno, highlighting emergency preparedness as a particular area where the site had to adapt their plans to ensure IRMA standards were being met. "We had a robust emergency-preparedness plan in place, but IRMA requires you to really engage in a lot of dialogue with the community to make sure the plan is going to meet their needs and that they understand potential impacts," she adds.

On the environmental side, Albemarle had to conduct an extensive air-quality study at the Salar de Atacama to help bolster IRMA standards compliance. To help with energy demand for DLE, the site recently completed transmission lines to deliver renewable energy to the salar. Furthermore, efforts are underway to minimize freshwater consumption and increase the potential for brine re-injection in the salar. "Through our current process, we concentrate the brine and there isn't any possibility to inject the brine back into the salar. So, we need to ensure there won't be any unforeseen environmental impacts if we start re-injecting the brine. We're constantly monitoring the brine and water in the area," says Lenny-Pessagno. Another major infrastructure project at the site involves bringing desalinated water to the area — not just for Albemarle's use, but for multipurpose supply to industrial sectors and communities in the area.

Lenny-Pessagno believes that working toward IRMA 50 has been very beneficial for the Salar de Atacama. "When we took a step back after the audit process, we saw that the IRMA standard truly was a great playbook to make improvements in in our operation and ensure we're minimizing environmental impacts, while maximizing dialogue and transparency with community members. It's been a great choice that we made, and the investment and many, many people-hours, as well as things like the air-quality studies, have been well worth the effort." The work does not end once IRMA 50 is achieved. "There is an interim audit at 18 months and then a full-scale audit at three years, so it's not a process where you can rest on your laurels for the rest of the mine life. It is truly continuous improvement," she notes. Achieving IRMA 100 is the responsibility pinnacle for the mining industry. Albemarle's lithium-mining project in Kings Mountain, N.C. has set a goal to become the first IRMA 100 site in the world.

How much lithium is there?

Understanding the composition of brines can be challenging and time-consuming, as properties can vary widely depending on location and processing conditions. A new device, the Z-9 Liquidator (Figure 3), developed by SciAps, Inc. (Woburn, Mass.; www.sciaps.com), is said to be the world's first portable analyzer for lithium brines. "Currently, brine samples must be sent to off-site laboratories for analysis, which requires several weeks. With our system, results can be determined in a matter of minutes," says Don Sackett, CEO of SciAps.

Lithium brines are especially difficult to analyze when compared to other liquid streams. Typically, in-field elemental analysis employs X-ray fluorescence (XRF), but because of lithium's low molecular weight, the X-ray emissions are extremely weak,

making XRF impractical to use in the field, explains Sackett. The Z-9 uses a technique called laser-induced breakdown spectroscopy (LIBS), which fires a focused laser at a material, delivering an extremely high instantaneous power to vaporize the material, creating an electron plasma. "As the plasma cools over a microsecond time scale, the electrons recombine with the atoms, causing characteristic wavelengths of light to be emitted in the infrared, visible and ultraviolet spectral regions," notes Sackett. The wavelengths are unique to specific atoms, forming the foundation for measuring concentration.

The Z-9 has a built-in spectrometer to measure the wavelength and intensity of the emitted light, which can be used to produce a concentration measurement for lithium and other elements in the brine. Notably, the device requires only 1–2 mL of sample per test, and no dilution is required, so tests can be completed very quickly. "In order to make the device work properly, SciAps scientists had to modify the LIBS design to aerosolize the brine liquid, causing the plume of liquid to be injected in front of the focused laser to generate the plasma," adds Sackett. The Z-9 has been operating at large brine-processing operations in Chile and the U.S. Gulf Coast, as part of an extensive field-testing effort. Commercial units are currently under production.

Sorbent materials

One of the key technological considerations in lithium extraction is the selection of adsorbent method. Since there are so many physical considerations, from the temperature of the brine to the dilute lithium concentrations (brines will sometimes have more than 10,000 times higher sodium concentration than lithium), finding an optimal material to perform with high selectivity is challenging.

Researchers at Oak Ridge National Laboratory (ORNL; Oak Ridge, Tenn.) have seen very promising performance in extracting lithium from geothermal brine using iron-doped lithium-aluminum-layered double hydroxide chloride (LDH) sorbent and forward osmosis. "LDH sorbents can operate perfectly under geothermal brine conditions, around 95°C. Also, there is no need to add any reagents to adjust the pH for lithium extraction. It is a low-cost sorbent material with lithium-recovery rates greater than 95%," explains Parans Paranthaman, corporate fellow at ORNL. In partnership with the Critical Materials Institute at Ames National Laboratory (Ames, Iowa; www.ameslab.gov), ORNL has run column extraction using LDH sorbents for more than 500 h with

FIGURE 3. The ability to rapidly analyze brine concentration in the field will help to streamline lithium extraction

multiple lithiation and delithiation processes. Each column cycle involves loading the sorbent with lithium chloride from brine, intermediate washing to remove undesired ionic species and final unloading of lithium chloride ions. ORNL has scaled up the LDH sorbent manufacture to kilogram-scale batches, and the team is prepared to begin testing at geothermal sites in the future.

Another crucial benefit of LDH sorbents is the promise for reuse and recovery. "LDH sorbents can be reused after hundreds of runs. LDH sorbent can also be recovered quickly if there was any failure during extraction, since we don't need to add any reagents to delithiate, unlike ion-exchange sorbents or other solvent-extraction methods," says Paranthaman. Also, since they are based on aluminum, rather than rare or precious metals, overall system costs will be lower.

For the extraction of lithium from geothermal brines, researchers at Karlsruhe Institute of Technology (KIT; Germany; www.kit.edu) and Energie Baden-Württemberg AG (EnBW; Karlsruhe, Germany; www.enbw.com) have developed an ion sieve based on lithium-manganese oxide with a spinel crystal structure. They have tested the sieve using brines from the Bruchsal geothermal plant operated by EnBW in Germany's Upper Rhine Graben region. Crucial to the sieve's successful performance is the selection of desorption solution, which releases the adsorbed lithium from the sieve. According to KIT, acetic acid yielded the most promising results, balancing lithium extraction efficacy with adsorbent preservation. The next steps will be to improve adsorption capacity and proceed with scaleup from the laboratory to the pilot scale.

Beyond brines

Another promising source of extracted lithium is in wastewater from mining operations. In Finland, Weeefiner Oy (Jyväskylä, Finland; www.weeefiner.fi) and Sensmet Oy (Oulu, Finland; www.sensmet.com) have joined forces to develop the Intelligent Recovery Unit (IRU), a treatment solution to produce minerals like lithium from the waters at end-of-life mining sites. Typical treatment processes for mine waters focus on decontamination and precipitation, which produce contaminant-laden sludge that can pose difficulties with disposal.

Weeefiner's 4D Scavenger technology is designed to extract dissolved metals for reuse, so its application can drastically reduce the downstream water-treatment loads. For the IRU platform, the 4D Scavenger technology is combined with Sensmet's µDOES analyzer, which can provide realtime quantification of dissolved metal concentrations, such as Ni, Co, Li, Mn and Cu, in mining waters. In the IRU, the analyzer measures metal concentrations both before and after treatment with the 4D Scavenger, which supports automated process optimization. The companies are now collaborating with Rio Tinto (London, U.K.; www.riotinto.com) to prepare a field-ready version of the unit. ■

Mary Page Bailey

Focus on Pumps

Vacuum pumps with hygienic design for daily cleaning

The new DV 650 and DV 800 FP-r washdown vacuum pumps (photo) of the dry-running Dryvac series have been introduced for vacuum systems used in food and packaging applications. The new screw vacuum pumps require only a small footprint and little installation space, and they can be washed down inside and outside in any installation position. Their compact size and low noise level enable uncomplicated, near-machine installation in the immediate vicinity of the production line. The advantage for users: during daily cleaning of the system, the DV 650/800 FP-r pumps can be washed down with the production equipment in one process. This results in fewer system downtimes, better cycle times, less maintenance, a higher standard of hygiene and higher filling and packaging outputs, the company says. — *Leybold GmbH, Cologne, Germany*
www.leybold.com

This electric double-diaphragm pump is efficient

The Quantm pump (photo) features a new electric-motor design that is said to be up to eight times more efficient than a standard pneumatic pump. The pump is suitable for nearly any fluid-transfer application and offers a wide range of materials of construction to support multiple industrial and hygienic applications. The electric pump is designed for use as a drop-in replacement for current pneumatic pumps or for greenfield construction. With built-in controls and no gearbox, the pump also fits seamlessly into most fluid-transfer applications. — *Graco Inc., Minneapolis, Minn.*
www.graco.com

Multistage, double casing pumps for CCUS applications

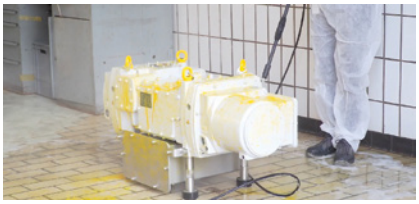
Introduced in February, the BB5 pump (photo) is fully compliant with API 610, and will be used in carbon capture, utilization and storage (CCUS) processes. The BB5 pump has the option to swap out individual stages in the future, giving users the flexibility to adjust their hydraulics. This provides each pump with a wide-ranging, advanced hydraulic coverage that engineers tailor to meet the needs for each application. Flowrates in excess of 1,000 m^3/h can be achieved, with heads greater than 3,660 m. The pumps can operate at temperatures up to 450°C and have a standard working pressure of 15,000 kPag. The pumps are available in API 610 table H.1 materials, and flange sealing options are available to match users' requirements. — *CPC Pumps International Inc., Burlington, Ont., Canada*
www.cpcpumps.com

These new plunger pumps have a compact design

This company has added two new compact plunger pumps to its portfolio, the P3-85 with a maximum power of 700 kW, and the P5-85 (photo), with a maximum power of 1,200 kW. The pumps feature an integrated gearbox and a short design, with a stroke of 100 mm and a rod force of 280 kN. The Px-85 series enables an increased performance compared to long-stroke designs. The short design, the elimination of external gears and the optimization of performance makes it possible to replace several pumps with one in some cases. Flowrates of up to 2,100 L/min for the P3-85, and 3,500 L/min for the P5-85. — *Uraca GmbH & Co. KG, Bad Urach, Germany*
www.uraca.de

Wastewater impeller combines efficiency and reliability

In a further expansion of its range of pumps suitable for handling untreated wastewater, this company has developed a new radial multi-vane impeller with an open design. The D-max impeller (photo) handles fluids containing solid substances, long fibers and coarse solids, as well as entrapped gas or air. It is therefore very suitable for handling untreated waste water, combined sewage, recirculated and heating sludge, as well as activated, raw and digested sludge with a solids content of up to 8%. This impeller type is also suitable for transporting fluids with a high viscosity. At approximately 84%, the new impeller's best effi-



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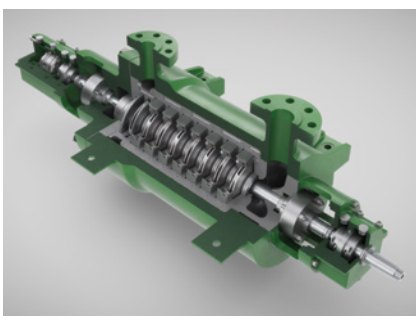
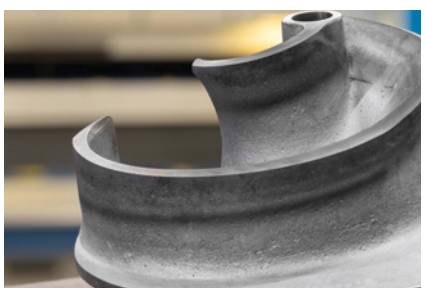


CPC Pumps International

Uraca



KSB

Tapflo

ViscoTec Pumpen- u. Dosiertechnik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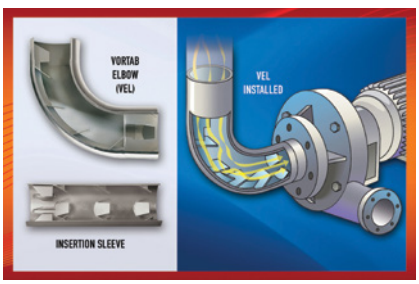


Vortab

ciency can be compared with the performance of closed multi-channel impellers, the company says. The D-max impellers are used in the Sewatec and Amarex KRT pump type series. The maximum head is approximately 90 m and the maximum flowrate is approximately 2,800 m^3/h. — *KSB SE & Co. KGaA, Frankenthal, Germany*
www.ksb.com

New lobe pumps for a wide variety of fluids

The new LPX lobe pumps (photo) are designed to meet the growing demand for high-performance and reliable flow solutions in various industries, including food and beverage, pharmaceutical, chemical and wastewater treatment. The LPX lobe pumps are suitable for handling a wide variety of fluids, including those with high viscosity, such as syrups, creams and pastes. These pumps are also highly efficient, with low pulsation and shear, making them ideal for delicate fluids that require gentle handling. The pumps are available in a variety of sizes and materials, including stainless steel, and they are easy to install and maintain, with minimal downtime required for servicing or repairs. — *Tapflo AB, Kungälv, Sweden*
www.tapflo.com

A dosing pump with more features, better performance

The vipro-PUMP series (photo) features a new design, optimized dosing components and modular construction, making it possible to adapt the dosing equipment to the application. The core of this new generation is the modular design of the dispenser. The separable rotor assembly allows fast installation and removal of its components, while variable rotor and stator materials ensure optimum dispenser performance. For example, a ceramic rotor with matching stator is suitable for abrasive media, while an HVC rotor is used for standard applications, such as adhesives. An enlarged pump inlet minimizes pressure loss, improves the material flow and allows easy attachment and detachment of the hose supply. The new stator design has an anti-rotation device and a defined non-positive connection to allow easy and intuitive assembly. Various drives can be attached to the dispenser using a locking ring and a newly designed coupling. — *ViscoTec Pumpen- u. Dosiertechnik GmbH, Töging am Inn, Germany*
www.viscotec.de

New drive system for diaphragm metering pumps

This company's ecodos series of diaphragm pumps (photo) now include a new form of wide-range speed control. Alongside asynchronous motors and servomotors, permanent-magnet synchronous motors (PMSMs), are also used now. They are characterized by high energy efficiency and a control range greater than 1:200. This significantly expands the range of applications. With PMSMs, it is no longer necessary to use several pumps for different flowrates or oversize asynchronous motors for low speeds. Since PMSMs can be designed without a fan, they are compact and easy to clean, which makes them suitable for hygienic applications. All materials in contact with the fluids used in the pump units meet FDA and USP Class VI requirements, and the E.U. directives for the food industry. High efficiency rating over the complete control range, in accordance with energy efficiency class IE5+, also reduces energy costs, thus ensuring a lower total cost of ownership. — *LEWA GmbH, Leonberg, Germany*
www.lewa.de

Consider flow conditioners when space is limited

The efficiency and service life of pumps can be greatly extended by following the manufacturer's installation recommendation for pipe straight run entering the pump. When cramped pump houses or restricted pipe runs make this impractical and costly, this company's flow conditioners can be used to deliver a uniform, swirl-free flow profile to the pump inlet in as little as three pipe diameters. The simple, flexible designs of the Model VEL elbow (photo) and the Model VIS insertion sleeve configurations provide a cost-effective, easy-to-install solution that supports proper pump installation. The conditioners can be made from carbon steel, 316L stainless steel or Hastelloy C-276 and in almost any pipe size. A variety of process connections are also available, such as ANSI flanges, male NPT threads, butt-welded preps or retaining wafers. — *Vortab Co., San Marcos, Calif.*
www.vortab.com

A new calculator tool for selecting vacuum pumps

A new vacuum-calculation tool (photo) is now available to identify specific vacuum products for various applications. The calculator provides evacuation and pump-down curves for different pump technologies and also performs different calculations for self-configured pumping solutions. Users simply input the technical parameters in order to find matching products, and to compare different vacuum solutions. The vacuum calculator can be used via the company's website, which also provides videos describing how to use the tool. — *Pfeiffer Vacuum GmbH, Asslar, Germany*

www.pfeiffer-vacuum.com

Inlet traps help prevent premature pump failure

PosiTrap vacuum-inlet traps (photo) feature a fully positive seal at both ends to prevent contaminants from entering the pump, potentially causing premature failure. The traps come in sizes of 4 and 8 in. for pumps with capacities of up to 25 and 50 ft^3/min, respectively. Made of stainless steel with straight-through and right-angle ports and flange sizes from NW 25 up to ISO 80, they can be supplied with a wide variety of filter elements. Designed to protect pumps from particulate matter, organic solvents, hydrogen peroxide, acids and water vapor, filter media offered for PosiTrap traps include stainless-steel mesh, activated charcoal, molecular sieve, polypro and Sodasorb. — *Mass-Vac, Inc., North Billerica, Mass.*

www.massvac.com

A new pump brand for biotechnology applications

This new brand brings together its parent-company's pumping, flow-measurement and flow-metering technologies (photo, p. 20). Included in this new brand are the Quaternary (four-piston) Diaphragm Pumps, which are suitable for transferring shear-sensitive aqueous solutions and biological materials, while being clean-in-place (CIP) and sterilize-in-place (SIP) capable. The single-use models

Pfeiffer Vacuum

Mass-Vac

PSG Biotech

Pompetravaini

Siemens Large Drives Applications (LDA)

are equipped with a product-wetted plastic pump chamber that can be replaced as a complete unit for disposal. — *PSG Biotech, a brand of PSG, a Dover company, Oakbrook Terrace, Ill.*
www.psgdover.com/biotech

Self-priming centrifugal pump for liquefied gases

The pumps usually used to handle liquefied gases, such as ammonia, liquefied petroleum gas (LPG) and refrigerants, are self-priming with a side-channel design from this company's TBH or TBA series. The suction and discharge casings of these pumps are designed to withstand higher pressures (up to 40 bars) and the pumps are able to transfer liquids with the presence of gas. In particular the TBA (photo), with an additional centrifugal stage at the suction, achieves very low net positive suction head (NPSH) values and it is particularly suitable for pumping fluids close to their boiling point. To ensure no leakage to the outside when handling toxic and hazardous fluids, the company's magnetic drive pump (TBK or TBKA series) is an alternative to pumps with double mechanical seals. — *Pompetravaini S.p.A., Castano Primo, Italy*
www.pompetravaini.com

IoT platforms for enhanced centrifugal pump operations

Last month, this company and Sulzer signed a letter of intent to cooperate in providing operators of large centrifugal pumps with an enhanced digital service. Bringing together their respective IoT-platforms and services, Sidrive IQ and Blue Box (photo), the two companies are collaborating to deliver an integrated solution that improves equipment reliability and cuts operations costs. In order to offer a more holistic value-add that addresses the wider drivetrain, the pump-specific, AI-based analytics platform, BlueE Box, will now be complemented by predictive-maintenance data from Sidrive IQ, an IoT-platform for smart fleet management of drive systems and solutions. — *Siemens Large Drives Applications (LDA), Nuremberg, Germany*
www.siemens.com ■

Gerald Ondrey

New Products

A new two-channel AI/OI intrinsic-safety barrier

The new KCD2-SCS-EX2 (photo) is a two-channel, dual-function analog input (AI)/analog output (AO) intrinsic-safety barrier in a compact 12.5-mm housing. The two channels of the KCD2-SCS Series interface modules can be configured individually for analog input or analog output control signals. They are also HART compatible and can function as output drivers for smart valve positioners or as a power supply for smart two-wire transmitters. For analog input signals, the control side can be operated either as a current source or current sink via selectable DIP switches on the front panel. Each channel is configurable to allow positioner control on one channel (AO), and position monitoring (AI) on the second channel. Positioners ensure that the actuator is brought into a position specified by the control system. — *Pepperl+Fuchs Inc., Twinsburg, Ohio*
www.pepperl-fuchs.com

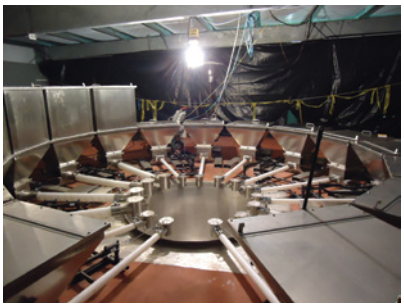
Pepperl+Fuchs

Automatically feed multiple ingredients to one location

Batch-weigh systems from this company can be configured to automatically transfer, weigh and dispense multiple materials fed from multiple locations to a common discharge location (photo). Integrating proprietary weighing technology, a programmable logic controller (PLC) and load cells with the company's flexible screw conveyor, the system is suitable for loading multiple powders, granules, flakes, pellets and other bulk materials into mixers, blenders, hoppers, tanks and containers, each in precise, preset amounts. The batch-weigh system achieves a 99% or better batch-weighing accuracy to ensure the mixture, blend and end product meet the targeted specifications. — *Automated Flexible Conveyor, Inc., Clifton, N.J.*
www.afcspiralfeeder.com

This platform delivers limitless asset health management

BKV Beyond (photo) is a new platform extending condition monitoring from edge to enterprise. Designed for optimal machine healthcare with verified actionable insights, BKV Beyond helps avoid costly downtime through BKV Collect wireless sensors. The sensors, fitting directly onto machinery, connect wirelessly for smooth and efficient installation. BKV Beyond securely centralizes all communications and data to share through the BKV Connect Gateways. The state-of-the-art BKV Beyond software utilizes artificial intelligence (AI) to quickly analyze data points, detecting faults before they become an issue. The BKV Beyond platform avoids unexpected outages and provides the confidence to extend maintenance intervals. All system upgrades are completed instantaneously without interrupting operations. — *Brüel & Kjær Vibro GmbH, Darmstadt, Germany*
www.bkvibro.com



Automated Flexibe Conveyor

Touchscreen automates powder induction, dispersion

The newest addition to this company's Fastfeed product lineup is the Fastfeed PLC model FF-425-PLC (photo), which features full automation controls and a touchscreen operation designed to increase efficiency and productivity even further. The Fastfeed PLC offers unique mechanical advantages, including rapid incorporation and wetting out of powder ingredients, coupled with a host of automation advantages, such as ergonomic touchscreen operation, recipe storage, monitoring job stats, remote capability for maintenance or updates, and one-touch cleaning-in-place (CIP) mode. — *Admix, Inc., Londonderry, N.H.*
www.admix.com

Brüel & Kjær Vibro

New and updated flow sensors for biotech applications

Last month at Interphex, this company introduced the BioProTT FlowSU system and updated Sumo-Flo CPFM-8103 single-use Coriolis mass flowmeter technologies (photo, p. 22). The BioProTT FlowSU System is a next-generation flow-measurement system that has been designed for single-use biopharma applications. The FlowSU System revolve around a disposable sensor that eliminates the need for calibration and can be easily integrated into most standard manifolds while performing flow-measurement and air-in-line

Admix

PSG Biotech

Heinkel Process Technology

Pfeiffer Vacuum

ProMinent

Rembe

detection tasks simultaneously. The sensor's straight-line flow path also produces product transfer with less shear stress to better protect sensitive fluids from damage. The SumoFlo CPFM-8103 is said to be the world's only gamma-sterilizable Coriolis mass flowmeter, and has a reading accuracy of ±1% in flowrates from 0.05 to 100 kg/min. — *PSG Biotech, Oakbrook Terrace, Ill.*
www.psgdover.com/biotech

New peeler centrifuge with patented features

The Bluetector is this company's new generation of horizontal peeler centrifuges. Features of the new brand include an optimized and patented housing shape (photo), which permits the efficient drainage of filtrate through the rear wall without any additional guidance for the liquid. A slidable machine cover reduces noise emissions and contamination of the technical area, providing quick and easy access. The Bluetector is equipped with only electric drives — also in hazardous areas up to ATEX zone 1 — ensuring excellent cleanliness without hydraulic oil and belt abrasion. The intelligent drive concept minimizes friction losses and enables the use of an optimized electric motor, without a belt drive. This means shorter batch times, lower energy consumption and lower operating costs, says the company. The new peeler allows low-shear and gentle product discharge and protects the discharge chute from contamination. — *Heinkel Process Technology GmbH, Besigheim, Germany*
www.heinkel.de

A new vacuum gage ensures process control and reliability

Many vacuum applications operate only within a specific pressure range. In order to operate such vacuum systems efficiently, the total pressure must be measured reliably. The analog vacuum gages in the ActiveLine have been upgraded to the latest state-of-the-art with a successor model to the Pirani/Bayard-Alpert PBR 260, the PRB 360. This new Pirani/Bayard-Alpert gage covers the pressure range from 5×10^{-10} to 1,000 hPa. Due to its compact design, the gage provides a space-saving way to incorporate it into vacuum process systems, analytical instruments, leak-detection systems and other applications. Two filaments offer enhanced operating reliability, process control and longevity. — *Pfeiffer Vacuum GmbH, Asslar, Germany*
www.pfeiffer-vacuum.com

Manage chemicals with this new radar level sensor

The Dulcolevel (photo) is a new radar level sensor that provides continuous information on tank liquid levels. This ensures tanks can be refilled on time without any process interruption and makes chemical inventory management remarkably straightforward. In parallel to this, a specific Inventory Management module has been added to the Dulconnex cloud platform. Thanks to both innovations, operators can now obtain a complete digital fluid-management system from a single source. The measuring range covers volumes of 30 to 1,500 L for any tank of up to 15 m in height, with an accuracy of ±5 mm. — *ProMinent GmbH, Heidelberg, Germany*
www.prominent.com

A graphite rupture disc for high temperatures

The GRX graphite rupture disc (photo) has been developed for processes with corrosive media, low and medium pressure and temperatures between –180 and 500°C (1,500°C in the absence of O_2). Thanks to the specially developed Pyro-Carbon (PyC) coating, the GRX rupture disc resists significantly higher temperatures, while remaining permanently leak-tight. With an operating pressure ratio of up to 80% and burst tolerances of ±10%, the GRX is usable for rupture pressures from 0.05 bar. Optionally, a vacuum or back-pressure support can be integrated, which is installed without adhesive (which melts at very high temperatures). The GRX is also available with a burst indicator, upon request. The installation occurs directly between the flanges or other clamp systems. — *Rembe GmbH Safety+Control, Brilon, Germany*
www.rembe.de

Gerald Ondrey

Control-Valve Emissions and Packing

Department Editor: Scott Jenkins

Fugitive emissions — defined as unintended releases of volatile organic compounds (VOCs) from process equipment to the atmosphere — have been a long-standing issue in the chemical process industries (CPI). Valves and pumps are two of the leading sources. With valves, the primary cause of fugitive emissions is failure of packing seals and gaskets, which are designed to maintain a seal between the valve bonnet and stem. This column describes potential solutions to address valve-packing failures.

Two of the most common ways to prevent fugitive emissions from valves are using live-loaded packing and bellows seals. Live-loaded packing, a method where a compressive force is applied to the packing material so that it tightly seals against the interior of the valve bonnet, can be paired with nearly any valve configuration to achieve very low leakage rates. Bellows seals are only available with sliding stem valves, but provide even lower leakage rates — near zero in most cases.

Seal selection

Seal-system selection is based on the specific requirements of the application, but some some general guidelines apply in most cases. Solutions emitting no more than either 500 parts per million by volume (ppmv) or 100 ppmv, depending on the location of the facility, are usually required. Live-loaded packing is sufficient in most cases to achieve compliance, but bellows seals are often used to further reduce (or even eliminate) emissions.

End users typically work with a valve vendor to determine the best solution for an application by balancing price and performance. Live-loaded packing is less expensive than, but not as effective as, bellows seals. When process media is lethal, volatile or radioactive, bellows seals are the industry standard because they prevent the stem and packing from coming into contact with the process media. The result is leakage rates down to 1 × 10^{-6} cm^3/s of helium.

Materials

When live-loaded packing is used, the material of choice is typically either polytetrafluoroethylene (PTFE) or graphite. PTFE offers near-universal chemical compatibility with many types of process media. It also provides very low friction, which allows for smaller sizing of actuators, but it has process-media temperature limitations. Typically, vendors use 450°F as the upper limit for PTFE packing.

Similar to PTFE, graphite is compatible with most process media, but graphite-based packing systems can be used in applications for VOCs where the process media temperature is up to about 750°F. Graphite also has the additional upside of being inherently fire-safe.

Some packing systems provide capabilities of both PTFE and graphite, making them the best fit in certain applications. This is achieved by using a layer of graphite packing rings closer to the process media, and a layer of PTFE rings farther away from the process media. These systems provide low friction and emissions, and in some cases, an API 589 fire-tested solution, for operation at process media temperatures up to 450°F.

Leak testing

For all types of valves, testing is required to ensure effectiveness in operation (Figures 1 and 2).

International Organization for Standardization (ISO) 15848 applies to both control and isolation valves, and has two components. A vendor test (ISO 15848-1) proves the capabilities of a technology, and a production test (ISO 15848-2) proves the production equipment meets the requirements while in operation. The testing requirements for ISO 15848-1 include compliance with several combinations of leakage classes, thermal cycles and mechanical cycles to qualify for certification.

ISO 15848-1 specifies use of either the vacuum or flushing "total leakage" measurement methods described in Annex A of the standard. Leakage is recorded as a leakage rate per measured stem size. ISO 15848-1 states there is no correlation intended between the leakage tightness classes, whether the test fluid is helium or methane. The other popular method to detect leakage is Method 21 from the U.S. EPA, which is also specified in ANSI/FCI 91-1. This method stipulates leakages between 500 and 100 ppmv.

Valve Type	Mechanical Cycle Class	Mechanical Cycles Required	Temp. Cycles
Control Valve	CC1	20,000	2
	CC2	60,000	3
	CC3	100,000	4
Isolation Valve	CO1	205	2
	CO2	1,500	3
	CO3	2,500	4

FIGURE 1. Testing for requirements for ISO 15848-1 include compliance with several combinations of leakage classes and thermal and mechanical cycles

ISO 15848-1 Leakage Tightness Classes	Measured Leak Rate (Annex A)	
	$mg \cdot s^{-1} \cdot m^{-1}$ of stem perimeter	$atm \cdot cm^3 \cdot s^{-1} \cdot mm^{-1}$ of stem diameter
AH	$< 10^{-5}$	$< 1.76 \times 10^{-7}$
BH	$< 10^{-4}$	$< 1.76 \times 10^{-6}$
CH	$< 10^{-2}$	$< 1.76 \times 10^{-4}$

Note: Leakage Class A is typically achieved only with Bellows designs.

Note: Leakage classes may be denoted by "BH" or "BM", etc to indicate the testing fluid. "H" indicates the test was performed with Helium per a leakage rate method. "M" indicates the test was performed with Methane using EPA Method 21.

FIGURE 2. Leakage is recorded as a leakage rate per measured valve stem size

Performing these leakage measurements in the field is both costly and time consuming, as it requires sophisticated listening devices operated by a skilled technician to detect leaks. But if a company has demonstrated success with detecting and correcting issues, monitoring-period extensions of up to one year, instead of every three to six months, can be implemented. For frequent offenders, monthly measurements need to be taken. Specifically, facility personnel must prove that no more than 0.5% of its total valve population has issues with stem or shaft leakages if they are to extend monitoring periods. ■

Editor's notes: 1) The content for this edition of "Facts at your Fingertips" was developed by Andrew Prusha, director – Chemical Process Industries, Emerson; 2) For more on valve emissions, see: www.emerson.com/documents/automation/control-valve-handbook-en-3661206.pdf.

Open Process Automation Offers Business Benefits

The Open Process Automation Standard (O-PAS) Business Guide makes the business case for the O-PAS. An example from the biopharmaceutical industry illustrates the benefits of interoperability and open process automation architecture

Kevin Finnan
Yokogawa

IN BRIEF

Normally, technical standards focus purely on technology. However, while envisioning the Open Process Automation Standard (O-PAS), the Open Group's (www.opengroup.org) Open Process Automation Forum (OPAF) realized that the concept spanned an entire ecosystem, which includes a broad range of business considerations as well as technical aspects (For more information on O-PAS, as well as interoperability and open process automation architecture, see Refs. 1 and 2.

To help address the business considerations of interoperability, OPAF organized a Business Working Group that operates in parallel to their other O-PAS groups, which address technology, enterprise architecture and certification. A team of authors in the Business Working Group has written the O-PAS Business Guide, Value Proposition and Business Case for the O-PAS Standard [*3*], which is outlined below.

O-PAS Business Guide

The O-PAS Business Guide covers not only an open process automation (OPA) business case and value proposition, which will clearly be requirements for any company considering a transition to OPA, but the document also provides guiding principles, quality attributes, and definitions of the roles of end users, systems integrators, and suppliers of hardware, software, solutions and services. The guide also outlines the value proposition for each of those participants and, most importantly, details benefits to a variety of vertical markets.

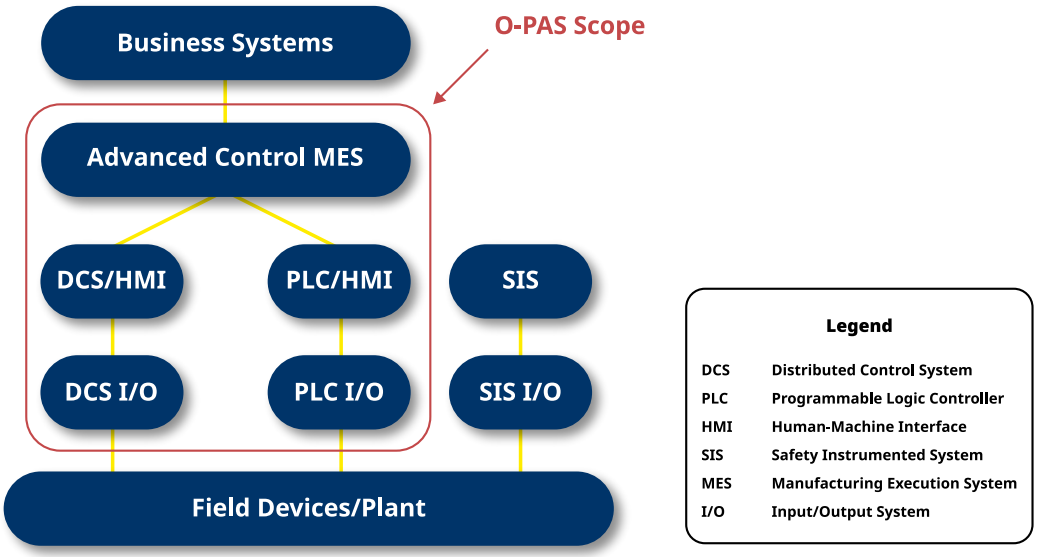


FIGURE 1. The O-PAS Business Guide provides guiding principles on, and definitions of, the roles of end-users, system integrators and software and hardware suppliers for open process automation

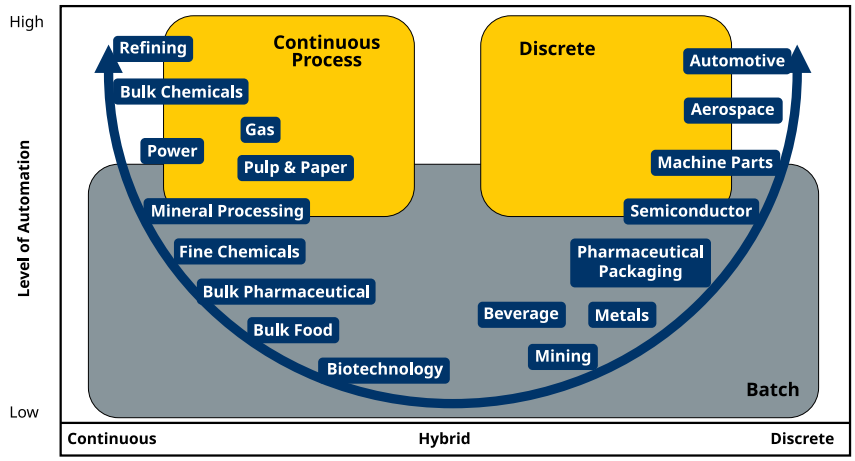


FIGURE 2. The initial O-PAS focus is on continuous and hybrid processing, and will expand to discrete manufacturing in the future

As the guide states, OPAF focuses on the standards and business guidance required to achieve interoperability, modularity and portability of a process control system's hardware and software components. The business advantages of these attributes are improved and more economical reuse of software components, an increased ability to apply innovative technology and enhanced management of hardware obsolescence. The O-PAS scope, in terms of industrial control system (ICS) components, is depicted in Figure 1.

Figure 2 illustrates the vertical market, or industry span. According to OPAF, the initial O-PAS focus is on continuous and hybrid manufacturing. Due to the equipment differences between those two types of manufacturing and discrete operations, OPAF plans to consider discrete manufacturing in the future.

OPA benefits for biopharma

The first of the "Business Scenario Examples" in Appendix C in the O-PAS Business Guide is entitled, "Biopharmaceutical Industrial Control System Integration and Qualification." It provides an illustrative example of business benefits of OPA. The biopharmaceutical business scenario describes a greenfield plant in which OPA enables manufacturers to readily automate an assortment of original equipment manufacturers (OEM) skid-mounted process units, such as centrifuges and fermenters.

OPAF has observed that the biopharmaceutical industry is constantly striving for a faster time-to-market for new products. The fact that industry economics reward the company that is the first on the market with a new product drives manufacturers to build and qualify plants as quickly as possible. However, during clinical trials, which are subject to high failure rates, manufacturers avoid committing capital until the latest stage possible. Once a clinical trial is successful, a company faces a very compressed timeline to bring a new manufacturing facility online.

This often compels the manufacturer to simply use the control systems that are delivered with the OEM process units, rather than risking delays, which could result from qualifying an entirely new system. As OPAF points out, re-engineering to a preferred supplier's system is expensive and time-consuming. Settling on the OEM skid suppliers' control systems requires the manufacturer or a systems integrator to develop custom interfaces to tie them all together but enables a faster time-to-market.

The guide continues to point out that biopharmaceutical companies are seeking seamless interoperability between control systems from different suppliers to reduce the time for project engineering and qualification. By simplifying the integration via a standard process-control architecture, biopharmaceutical companies can minimize the time necessary to build and qualify new plants.

The appendix concludes: *A standard, open process control architecture, as proposed by OPAF, would facilitate the connection of disparate automation equipment at the skid*

level to the higher-level control system. The inclusion of a universal data bus would allow seamless integration between systems provided by different vendors. Once in place, a control system developed under the standard architecture could be upgraded with minimal or zero downtime.

Although the appendix focuses on a greenfield scenario, the key points apply, as well, to brownfield cases. The open architecture and universal data bus would expedite the integration of existing equipment and process units that a manufacturer retrofits to incorporate a new product line. It would also greatly simplify the addition of emerging optimization solutions, such as advanced, real-time, artificial intelligence (AI)-based analytics.

Consolidated business scenario

The O-PAS Business Guide also includes a consolidated business scenario, which highlights benefits that are shared by a number of vertical markets. Many of these benefits are critical to the biopharmaceutical manufacturing industry.

Not only is a faster time-to-market essential for survival in the "new normal" business environment, but pressure to increase product quality while decreasing costs of production also continues to build.

Often, the capabilities of existing process-control systems are reaching their limits. Such systems, especially when they are proprietary, prevent end users from deploying the "best-in-class" software solutions that would enable them to address their key challenges in the most effective manner.

Another problem with proprietary systems is that components from different suppliers do not work together. Integrating process control systems from those suppliers is very difficult and costly due to the interoperability work involved. Seamless interoperability can substantially reduce direct and indirect costs. Direct costs result from the reduction in time needed for engineering development and support. Indirect cost savings result from the fact that operators do not need to learn to work with multiple systems. The industry has identified numerous risks associated with operators facing distractions and overloading.

The guide goes on to state that running and maintaining a facility is a challenging task. There is more emphasis than ever before on maximizing uptime and minimizing downtime, particularly, in the latter case, unplanned outages. A major benefit of OPA is that it simplifies technology refreshes and version updates. By minimizing the inherent risks in these projects, OPA keeps planned downtime as brief as possible and also enables updates with zero downtime.

The guide adds: *The maintenance of an O-PAS System is upgrade-by-repair, which means that the O-PAS conformant replacement component can be applied without interruption, without necessity to take the system out of service, will have the same capabilities as the component that is replaced, and may come with additional upgrades and improvements.*

OPA provides cybersecurity by design. The cybersecurity capabilities exceed those in today's control systems. Cybersecurity is embedded in the hardware, as well as in the software. A key benefit of the O-PAS Standard is that it ensures that all components are trusted and have enabled all the appropriate security capabilities.

Finally, the O-PAS Standard allows applications to be used in many systems. Secure portability enables the replication of intellectual property (IP) throughout the control systems as it is platform-agnostic.

Concluding remarks

Open process automation offers many opportunities for the biopharmaceutical industry. Most important is the improved production throughput for new medicines and therapies. OPA enables a faster time-to-market by expediting the integration of OEM skids in a modular manufacturing architecture.

This also greatly improves data collection, analysis and reporting. By settling on the control systems with which skid-mounted process units are supplied, the industry risks sacrificing the availability of data for analytics and optimization.

An OPA system also reduces production costs through lower costs and less time to integrate, configure, and implement process control technology. Manufacturers can defer capital spending to later stages in clinical trials.

Once production is online, OPA provides for reduced downtime by utilizing online upgrades and system expansions. Users will also find that open standards will simplify the integration of new technology via its process control architecture.

OPA provides seamless interoperability between control system components from a variety of manufacturers and system suppliers to reduce the time for engineering development and qualification as the result of the selection of broadly accepted communication standards. It allows users to rapidly integrate automation equipment from any number of suppliers in the industry.

OPA offers the capability to use "best-in-class" solutions from any supplier. Users are no longer limited to solutions from a single supplier. The best-in-class solutions could include, for example, AI-based advanced analytics in the "cloud" or at the "edge." These solutions allow users to accelerate their manufacturing process performance and quality while reducing costs. ■

Edited by Scott Jenkins

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Author

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Data Brokers Foster IT/OT Convergence and Interoperability

Obtaining the most value from data requires effective communications among industrial internet of things (IIoT)-connected devices that allow integration between operational technology (OT) and information technology (IT) systems. Data brokers play a key role in allowing communication between the two areas

Ravi Subramanyan
HiveMQ

IN BRIEF

Data sets have become a critical asset at chemical manufacturing facilities, and is the currency that enables chemical process industries (CPI) companies to benefit from Industry 4.0 technology. In most digitalization applications, data originate from controllers, programmable logic controllers (PLCs), gateways and edge-computing devices, and move toward advanced manufacturing technologies, such as artificial intelligence (AI), digital twins, augmented reality (AR) and others. This flow of data enables integrated, autonomous and self-organizing manufacturing systems.

In order to convert data into plant and process wisdom, there are several key challenges that need to be addressed. One significant challenge is integrating operational technology (OT) systems with information technology (IT) systems by efficiently bridging the two areas. Industrial internet of things (IIoT) tools and data brokers play a very important role in ensuring that the data are available for advanced use cases that allow chemical manufacturing organizations to fully benefit from Industry 4.0 technology. This article discusses the role and operation of data brokers in IT-OT integration.

Data maturity model

Data have become an essential component of chemical manufacturing as companies work to digitally transform and adopt Industry 4.0 tools. Chemical companies are generating vast amounts of data every day, from laboratory experiments to supply-chain management. These data have the potential to help chemical manufacturers make better-informed decisions, optimize processes and

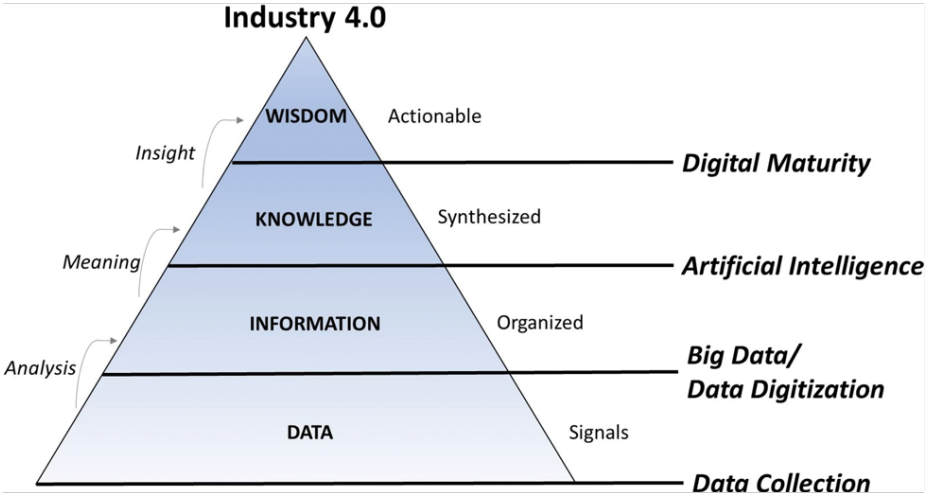

FIGURE 1. Digital maturity is indicated by the ability to transform raw data collected from a device into actionable information for decision makers

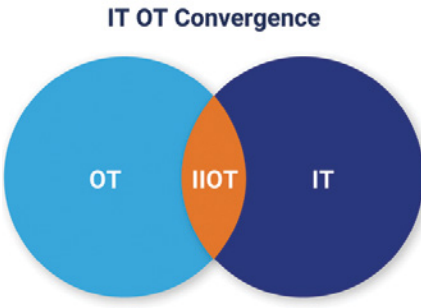

FIGURE 2. Information technology (IT) and operational technnology (OT) systems need to communicate easiliy to enable Industry-4.0 initiatives

drive business growth.

In addition, the chemical manufacturing industry is required to comply with a complex set of government regulations. An effective compliance program is essential to prevent business disruptions and loss of reputation. As a result, chemical manufacturers must maintain strict quality control, detailed product information, and a continuous integration of the data between OT and IT systems.

Due to the drive toward digital transformation, plus the need for regulatory compliance and quality control, data and analytics capabilities in the chemical manufacturing area have leapt forward in recent years. The volume of available data is growing exponentially, and more sophisticated algorithms have been developed and computational power and storage have steadily improved. Therefore, instead of intuition, the new normal is to rely on data to drive digital innovations and business decisions. Indeed, data are the "most valuable resource" for chemical manufacturing organizations.

Industry 4.0 brings together advanced manufacturing technologies like AI, machine learning (ML), digital twins, AR and virtual reality (VR) to enable integrated, autonomous and self-organizing manufacturing systems that operate independent of human intervention. Chemical manufacturing machine and process data can be analyzed by algorithms and used for critical real-time business and operational decisions that directly help achieve higher overall equipment efficiency (OEE), enable remote monitoring, reduce carbon footprint and enable product innovations.

The journey from data collection to digital maturity in chemical manufacturing is one in which analysis, context and insights are added to transform raw data captured from a device or system into information, knowledge, and finally, actionable wisdom for decision makers in the facility (Figure 1).

First, data are collected from chemical manufacturing processes and equipment, such as boilers, heat exchangers, tanks, furnaces and so on. They are then normalized, digitized, and organized as "big data." Next, meaning is added and data are synthesized into knowledge via AI. Finally, the data are transformed into actionable wisdom attained through the combined insights of digital maturity.

IT-OT communication

The first and most significant frontier to achieve digital maturity for Industry 4.0 is data collection and data movement. Data from chemical manufacturing machines, processes, and environment are captured via sensors and stored via several key technologies. On the OT side, data are stored with controllers, PLCs, gateways and edge devices, and on the IT side with a data center or enterprise cloud. Data storage technology enables the long-term storage of digitized data captured from advanced sensors. This data-rich environment enables advanced initiatives such as ML, AI, adaptive control and digital twins.

There are some challenges to data collection and data movement in chemical manufacturing. Machines and processes in the chemical manufacturing plant are heterogeneous and use various protocols to communicate. Data generated during chemical manufacturing can vary significantly in terms of format, quality and completeness. This can make it difficult to collect, integrate, and analyze data effectively.

Data connectivity is also a major issue due to the archaic, legacy nature of factory systems. As a result, typically IT and OT systems do not have an easy way to communicate to enable Industry 4.0 initiatives (Figure 2).

IIoT, a subset of Industry 4.0, uses smart sensors and actuators along with software to consolidate data to enhance manufacturing and industrial processes. IIoT is a key enabler to achieving IT-OT convergence, and the interoperability of the various communication protocols. It does it by creating a data abstraction layer in the middle and a common data language to translate the various communication protocols to enable interoperability.

This IT-OT convergence is important because success in today's connected industrial landscape hinges on collaboration. IIoT is changing how manufacturers work, blurring the lines between IT and operations. For example, IT professionals might now spend more time working with equipment on the factory floor, while OT teams will need to focus on cybersecurity and networking best practices. IT-OT convergence isn't about turning IT professionals into heavy machinery operators or plant engineers into data scientists. Rather, it is about creating a strategy

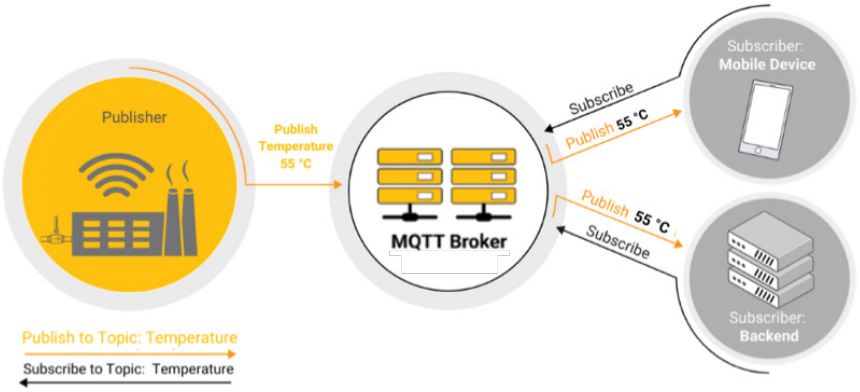

FIGURE 3. Data brokers are intermediary entities that enable OT annd IT cliient systems to communicate with each other

that bridges the gap and allows organizations to improve operational performance by working around a unified set of objectives and key performance indicators (KPIs).

Data brokers

A key technology enabler for IIoT to facilitate this data abstraction layer is a data broker. A data broker is an intermediary entity that enables OT and IT client systems to communicate with each other. Using an underlying standard, such as MQTT (message queueing telemetry transport), a data broker supports the ability to have multiple clients connected

A data broker is an intermediary entity that enables OT and IT client systems to communicate with each other.

that are publishing data and multiple clients that are subscribed to receive the data, such as enterprise applications (Figure 3). The clients communicating with the broker can abstract the underlying protocol that the machines and processes use to communicate. The broker works well in low bandwidth environments with unreliable communication mechanisms due to the underlying publish/subscribe method where machines and processes do not need to keep polling to get the data.

MQTT is an open-source messaging protocol for machine-to-machine communications. It is a standard binary publish-subscribe messaging protocol designed for fast and reliable data transport between devices especially under very constrained conditions. Constraints include unreliable network connectivity, limited bandwidth, limited battery power and so on. It is built on top of TCP/IP which is the go-to communication protocol to interconnect network devices on the internet. MQTT is ideal for IIoT due to the above-mentioned reasons.

The MQTT data broker is able to securely communicate the data between publishing clients typically on the OT side to subscribing clients on the IT side. For example, a streaming analytics application might want data from the SCADA system to run its analytics and publish real-time results. The application would run an MQTT client that is subscribed to the broker. The SCADA client would publish data to the broker when available. As a result, the streaming analytics application subscribed to the broker would automatically receive the updates without needing to poll for the data.

MQTT technology is designed to push data to and from thousands of remote devices across numerous sites to the enterprise. Sparkplug

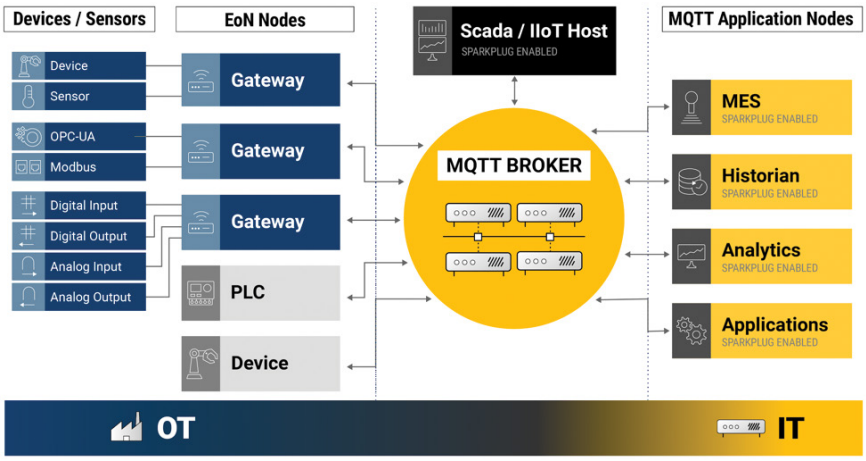

FIGURE 4. In an MQTT Sparkplug-based data architecture, the data broker connects multiple machines to enable bidirectional data movement

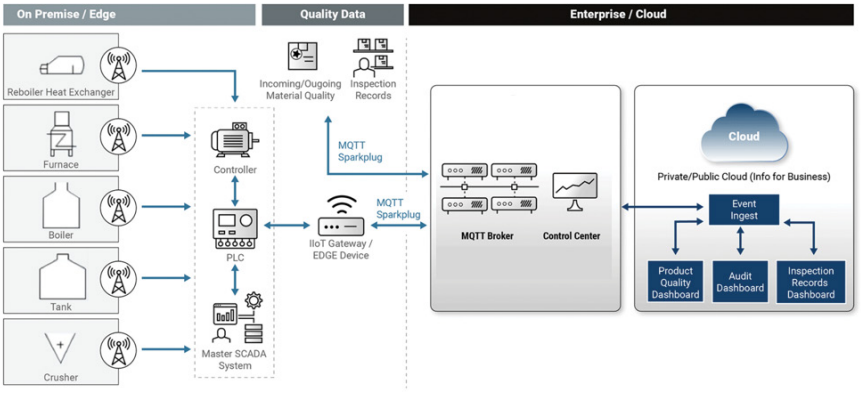

FIGURE 5. The diagram shows how data collection and movement could be managed at a chemical manufacturing facility

is a framework that sits on top of MQTT to add more context to the manufacturing data. It is an open-source software specification that provides MQTT clients with a framework to integrate data and provide context by defining data models. It provides a consistent way for equipment manufacturers and software providers to share contextual data, accelerating the digital transformation of existing operations.

Sparkplug allows IIoT deployments to decouple the data between hardware and software sources. With Sparkplug, new data sources are immediately discoverable to other system components and these sources can become a single source of truth. Sparkplug is fully secured, requiring no open ports for new devices and requiring TLS for all data transport.

Figure 4 provides an MQTT Sparkplug-based data architecture that shows how the data broker connects multiple machines and processes, and applications to enable seamless bidirectional data movement. This architecture solves the chemical manufacturing challenges of data integration and real-time data movement while providing efficient and secure data transfer to support digital transformation initiatives.

Figure 5 shows an example of how data collection and movement is managed in a chemical manufacturing plant to enable a product traceability use case. For any chemical manufacturing firm to maximize profit margins, it is crucial to have adequate controls over the process, quality, and delivery of its products. Traceability programs can play an integral part in this process by locating problems (and potential issues) with product quality at the earliest stage possible. Chemical manufacturers are often concerned about ensuring product quality and safety for the final product delivered to customers. However, most overlook "outbound traceability" — the complex process of monitoring raw materials as they transform into a sellable product. It may not be required, but it can put chemical manufacturers ahead of the competition by building a better relationship between a business and its clients during each step of the supply chain process. An MQTT-based data broker enables this product traceability use case by ensuring that data collected by PLCs at the edge from boilers, furnaces, and other devices, is combined with product quality and inspection records coming from other applications, like enterprise resource planning (ERP) and manufacturing execution systems (MES). The result is a single source of truth for all of the chemical manufacturing product traceability data to enable better product quality and increase in profit margins.

Concluding remarks

When harnessed correctly, data are the most valuable asset for many organizations, particularly in chemical manufacturing. In order to achieve the most benefit from Industry 4.0 technology, data need to be transformed to wisdom. A key initial step toward this journey is data collection and movement. When it comes to bridging data efficiently from OT systems to IT systems, IIoT and data brokers play a key role to ensure that the data are available for advanced use cases. MQTT and Sparkplug technology based solutions can help users solve their data collection and movement problem, allowing them to focus on the advanced data-analytics use cases to optimize their factory operations. ■

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Filtration Considerations for CPI Facilities

Numerous factors are taken into account when designing a filtration system, including technical, logistical and safety considerations

Ulrich Latz and Wim Callaert
Eaton's Filtration Division

IN BRIEF

Filtration is an essential step in the production and processing of many materials in the chemical process industries (CPI). Beyond the efficacy of the filtration solution itself, there are other complexities that chemical engineering facility operators should understand (Figure 1). This article looks at some of the lesser-known factors that make proper filtration in chemical manufacturing and processing applications a multifaceted challenge, but one that can be solved with the right filtration technologies.

Contamination issues

Each chemical process presents unique considerations for filtration, where the presence of contaminants can interfere with sensitive reactions, leading to decreased quality of the desired output product. Particulate-matter removal for feedstocks and ancillary fluid circulation are vital, because impurities can also corrode and damage the internal surfaces of process equipment, leading to costly maintenance.

Imputities severely threaten operational performance in interconnected chemical processes, as inefficiencies in one area can quickly propagate to others. Installing appropriate filtration solutions at key process points helps to reduce these risks and curb expenses while improving end-product quality.

Whether by purifying feedstocks, filtering process fluids for reuse or for final purification, chemical facilities rely on many types of filtration systems to accomplish the desired separation. While the design and operation of these systems can vary greatly, there are common considerations for all filtration systems that are important to understand, as discussed in following sections.

Quality materials

Although filtration systems all strive to achieve the same goal, quality materials are integral for ensuring the best results (Figure 2).

Filters are typically made from various plastics, polymers and fibers containing different additives and surfactants. For the automotive paints-and-coatings sector especially, filtration products must be silicone free, including materials of construction and the full production process. "Silicone free" can mean different things to different users; however, regardless of whether it is a filter bag or filter cartridge, the product must not contain silicone or various other crater-forming substances. In sufficient volumes these impurities can cause finishes to "crater away" from the contaminant, or they may cause paints and coatings to lose adhesion.

The potential diffusion of leachable substances into chemical processes is why it is critical to ensure that the filter media are free of impurities. Facility operators should seek an assurance from their suppliers, who can, in turn, offer complete traceability into the filtration products, including lot numbers and supplier sources. Furthermore, all products should exhibit a globally consis-

FIGURE 1. Proper design and maintenance of filtration systems in chemical manufacturing and processing operations are critical. So too are the use of quality products, attention to operator safety and knowing when to lean on experts for assistance


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FIGURE 2. Industrial filters must be made from materials that meet the stringent safety, sanitation and quality requirements for industries like paints and coatings, and specialty chemicals

tent quality, where product designs and materials do not waver in terms of performance, safety or dependability — regardless of where they are made.

Filters with oil-adsorption capabilities can further offer a solution to paint manufacturers that must ensure batches remain fit for end-customer use. Pure non-lubricated plastics, such as polypropylene, feature oleophilic and hydrophobic characteristics that attract oils to their surface while repelling water particles. These filters are commonly used in paint baths within the automotive industry, either as a remedy or preventive measure.

Environmental safety

In many CPI facilities, system operators must wear protective gear, including masks, to change out dirty consumable filter media, such as filter bags and filter cartridges. Limiting maintenance intervals at these points to the bare minimum is important, since volatile organic compounds (VOCs) can be released when opening filtration units to change consumables. VOCs can be either naturally occurring or synthesized, but tend to have high relative vapor pressures, meaning they easily evaporate when exposed to air.

Maintenance needs will largely depend on the type and capacity of the selected filtration equipment. Filtration systems must be designed and adequately sized to operate for long intervals between changeouts. Often the goal is to go weeks or even months between changeouts of consumable filter media. This helps to limit the risk of introducing industrial solvents into the production environment each time a unit must be serviced.

Facility operators are advised to consult an industrial filtration expert about options for large-capacity systems or, in other cases, automatic self-cleaning systems (Figure 3) that greatly reduce the need for manual intervention. The market offers many configurations and features that can extend the time between consumable filter changeouts — an expert can help you strike the right balance between frequency and dollars spent.

Also, housings for filtration units — as long as they are pressure vessels — must be properly certified. The American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC) and the Pressure Equipment Directive (PED) are two major standards that ensure the safe operation of pressure equipment worldwide. The ASME BPVC was established as a set of procedures for the design, manufacture and use of boilers, pressure vessels and piping, and is used in the U.S. and Canada as well as in many other countries. PED is an E.U.-based regulation that imposes similar safety and design requirements for pressure equipment.

These regulations further define design and safety parameters for filtration systems, fluids in use and system operating and ambient conditions. In all cases, it is important to ensure a filtration solution carries the required stamps and approvals by third parties, denoting the equipment has been built to the highest level of safety and has undergone assessment. At times, required certifications may further demand CE marking in accordance with PED based on the EN 13445 or AD 2000 pressure vessel codes.

Other considerations

Many factors affect the efficiency and effectiveness of filtration processes in chemical manufacturing and processing applications. These include the size of the particles to be filtered, filter media pore size, fluid viscosity, system temperature and pressure, and the concentration of the suspension. To ensure optimal performance, industrial filtration systems must be designed to account for these requirements.

For instance, a filtration system can be too efficient — and costly — if desired substances are filtered out along with impurities. Particle sizes can range from as small as 0.1 µm (for example, bacteria) to


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FIGURE 3. Automatic mechanically cleaned filters, like this commercial system, can provide continuous flow, simplified maintenance and worry-free operation because there is less risk of harmful VOCs being released in the production environment

as large as 2,000 µm (for example, sand grains).

End users must first assess which parts of the containment are undesired and which can be permitted. This is critical in choosing the best and most economical filter type, grade and size. If the filter media pore size is too small, for instance, premature clogging may occur, and if the pores are too large, impurities may pass directly through the filter.

The amount of contaminant will also play an important role in the sizing of the equipment. In some cases, a simple consumable filter with a nominal media configuration can perform effectively, and at other times, one or more multi-bag housing configurations having high-capacity media may be required. The market offers a vast line of products so that end users can find an optimal fit for each application.

Very high contamination loads may also influence end users' choice toward an automatic filtration system (Figure 3). These systems function without consumable or disposable media and are based on a backflush or mechanically cleaned design that keeps them operating continuously without stopping to change the filter medium. Other factors include the following:

Viscosity. Of further note is that the viscosity of a fluid affects the pressure drop across a filtration system. The greater the viscosity, the higher the pressure drop, due to the increased resistance to flow. In turn, the amount of time it takes to complete the filtration is increased. This pressure drop must be factored in when designing a system as higher-viscosity fluids can place high levels of stress on the filter, possibly damaging it.

Temperature. Low operating temperatures meanwhile can slow down the flowrate, requiring a more powerful pump and more robust filtration materials to handle the increased pressure from within the system. At high temperatures, things can get even more complicated. Excess heat may require additional cooling elements to keep the fluid within safe operating temperatures, as well as to avoid

FIGURE 4. Consider an industrial filtration system wherever there is possibility for contamination on process lines. Upstream filtration can help to minimize operational costs by protecting more expensive downstream filters

frictional losses.

Pressure. Likewise, where operating pressures are too low, the flowrate of the fluid will decrease, and the filtration system may not be able to effectively remove impurities. Conversely, if the pressure is too high, then the fluid's velocity will increase significantly, leading to a process that is too fast and can damage system components. For these reasons, some filtration systems are designed with regulators to adjust pressures to desired levels.

Environmental impact. One important trend linked to industrial filtration processes is reducing environmental impact and cost risk by minimizing chemical and water waste generation. Properly engineered filtration systems can play a key role in assuring that wherever disposable filters need to be used, the filter is sized optimally to fit the batch size, or, in other cases, that automated filters generate minimal backwash volume and/or purged waste concentrate.

While these are routine challenges, it is impossible to predict all the complexities that can impact chemical manufacturing and processing operations. For this reason, companies are advised to consult with specialists who have solved the same challenges many times before and can troubleshoot problems, anticipate facility needs and advise a correct solution from the start.

Best practices

Additional best practices for industrial filtration can be broadly applied to all CPI facility challenges and include the following:

Considerations for quality in, quality out. Filtration should take place before and after a chemical manufacturing process has been completed, requiring filters at liquid entry and exit points (for instance, at loading stations before liquids are transferred to tankers and again as trucks unload). Any time chemicals are transferred, filtration should be employed on each end to guarantee the quality of the product (Figure 4).

Furthermore, filtration systems should be in strict compliance with industry codes and standards. This ensures that the system is working properly and will pose little risk when it is installed and with minimal disruption to the environment (thus also helping to reduce the risk of contamination; Figure 4). It should also be configured in such a way that future maintenance can be carried out easily.

Considerations for operator safety. For liquid filtration systems, such as bag and cartridge filter housings, that need to be opened and closed for consumable replacement, operator safety and ergonomics need to be factored in. The height at which a filter housing needs to be opened and where the consumable needs to be extracted from is a typical example. For instance, where filter housings are normally positioned in a vertical setup, an inclined or even horizontal position may dramatically reduce the working height.

The method of opening and closing the filter unit can make a difference as well. Where traditional units are often equipped with multiple bolts, more operator-friendly, quick-opening-and-closing systems can be chosen to access consumables in seconds as opposed to minutes of difficult manual labor (Figure 5). Note that units should be equipped with a proper safety system that blocks the quick-opening mechanism while the housing is under pressure.

High-capacity filters, offering extra filtration surface in the same filter housing, can also minimize needed maintenance cycles and as such, reduce operator exposure to potential hazardous environments.

Finally, ample space must be provided for operators and maintenance personnel to access and maneuver around the filtration unit in such a way that minimizes exposure to other safety hazards within the environment.

Concluding remarks

In terms of revenue, the global industrial filtration market was estimated to be worth $33.5 billion in 2022 and is poised to reach $45.2 billion by 2027, growing at a compound annual growth rate (CAGR) of 6.2% [*1*]. The market is presently driven by a host of factors like those discussed here, including government enacted environmental regulations, more stringent requirements for safe environments and the increasing need for process reliability. These factors are driving demand for high-integrity, high-performing filtration solutions.

Great care must be taken when implementing filtration systems in CPI facilities. Engaging an expert to design the filtration system is a wise investment. An expert designer will be knowledgeable about the technical aspects of the filtration solution, can customize the setup to the facility's specific requirements and can minimize the risks associated with inadequate filtration measures. They will also be up to date on the latest industry standards and technologies and can suggest the most effective approaches. Additionally, they will ensure that the design falls within all industry requirements and

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FIGURE 5. In CPI plants, operators need bag filtration solutions that are simple and safe to use like this multi-bag filter housing that features quick opening and locking mechanism. Standing in place, the operator can rotate the hand wheel and open the cover. There is no requirement to have full movement and access around the housing or use any tools as with conventional bolted closures

safety guidelines.

Designing, implementing and maintaining filtration solutions for chemical manufacturing and processing applications are rarely straightforward processes. Companies seeking to optimize their outputs will benefit from high-quality filtration products and the assistance of industrial filtration experts who know everything there is to consider. ■

Edited by Gerald Ondrey

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The seventh annual Connected Plant Conference (www.connectedplantconference.com) — presented by *Chemical Engineering* and sister publication *POWER* Magazine — is taking place at the Marriott Canal Street in New Orleans, La. on Jun 25–28. The event will bring together industry experts to discuss practical advances in digitalization and industrial internet of things (IIoT) technologies in the chemical process industries (CPI) and power generation sector.

No matter where an organization is in its digitalization journey, Connected Plant Conference offers opportunities to gain valuable knowledge and skills that increase the chances of success. With a wide array of technical presentations and networking sessions, the conference will cover the entire gamut of cutting-edge topics driving practical digital transformation, including cybersecurity, artificial intelligence, remote monitoring and much more. CPI companies who will be presenting at the conference about their digital transformation progress include:

- Evonik
- ExxonMobil
- Albemarle
- Covestro
- Celanese
- BP
- BASF

Connected Plant's technical program will officially kick off with an intensive keynote session, "Quantum Computing: Going Beyond the Buzzwords." A series of expert speakers will address the current capabilities and future potential of quantum computing, which uses the principles of quantum mechanics to perform complex calculations more rapidly than traditional computing solutions. Clearly, the types of complexities encountered in CPI operations are prime candidates to benefit from quantum technologies.

The event also features a Digital Arena, where the industry's leading technology providers will present hands-on demonstrations of their products and provide practical guidance to engineers looking to implement advanced new solutions.

"Digital technologies are already having an impact on process safety, energy efficiency and asset reliability at chemical manufacturing sites of all types. But across the scope of the CPI, digital technologies have not come close to reaching their full potential, and the digital transformation remains in its early stages for large swaths of the CPI. Identifying opportunities for digital tools at plant sites, as well as developing solutions and scaling up successes, is challenging, and achieving success requires specialized knowledge, specific skills and organizational culture change," says *Chemical Engineering* senior editor Scott Jenkins.

The benefits of digitalization touch all aspects of operations, from economics to efficiency to environmental, social and governance (ESG) considerations. "Advancements in digital technologies are leading the innovation charge today and having a verifiable impact on the efficiency, reliability and safety. On a larger level, digital tools could optimize grid operations and help more efficiently integrate low-carbon resources, allow utilities to collect detailed real-time data on energy consumption and grid performance, optimize energy storage capabilities and even respond to changes in demand and supply," notes *POWER* senior associate editor Sonal Patel.

Networking opportunities abound at Connected Plant, with plenty of offsite options to explore the unique atmosphere of New Orleans. From guided food tours to local wildlife, connect with industry peers while enjoying the city. The social schedule also includes a Mardi Gras masquerade party and a poolside cocktail hour.

Another highlight of the event is the announcement of the Game Changer Awards, which recognize outstanding achievement in digitalization projects. Previously, the Game Changer Awards have honored truly cutting-edge digitalization projects executed by Chevron Phillips Chemical, Northrop Grumman, Covestro, Fero Labs, Eastman Chemical, Emerson, 3M, Shell, Henkel, ABB and more. ■

Mary Page Bailey

The Selection and Design of Fixed-Bed, Axial-Flow Vessel Internals

Follow these key considerations when deciding which internals to use in fixed-bed, axial-flow vessels

Eugene A. Kuchta
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Fixed-bed, axial-flow vessel internals are installed in natural gas plants, petroleum refineries, petrochemical plants, chemical plants and industrial gas facilities. Thermal-swing gas and liquid dehydrators, treaters and purifiers, along with non-regenerative mercury- and sulfur-removal units are commonly installed in natural gas plants. Fixed-bed catalyst units are installed in refineries and petrochemical plants, along with thermal-swing dehydrators, treater, purifiers, non-regenerative purifiers and treaters, and pressure-swing adsorption units. Chemical plants typically have thermal-swing and non-regenerative process units. Industrial gas plants utilize pressure-swing, thermal-swing and non-regenerative processes to produce high-purity hydrogen, oxygen, nitrogen and helium.

Selection and design

When selecting and designing vessel internals for a fixed-bed, axial-flow process, the initial capital cost of a particular internal should be balanced with its durability and its impact on the installation, maintenance and turnaround schedules. Choosing the lowest cost internal may result in unexpected consequences. If an internal component's durability is low, then frequent repairs or replacement may be required, which will result in extended turnaround schedules. The design needs to ensure that an internal component allows for an easy installation. Input from the operations and maintenance group should be solicited.

Internal materials for pressure-swing, thermal-swing and non-regenerative process applications are examined in the next section; specifically the inlet-flow distributor, the outlet-flow distributor and the support grid.

Pressure swing. Pressure-swing units typically operate on very short cycles (minutes) and have long run times between media replacement, usually longer than 10 years. Internals in this process application need to be very durable to withstand these pressure changes and possible operational upsets. Otherwise, unplanned shutdowns will result in lost production time, replacement media cost, and the cost of repair or replacement of the internal components.

Thermal swing. Thermal-swing units typically operate on cycle times of eight hours or greater; however, some processes run on shorter cycles, and the schedule for replacement of media is three to five years. Internals need to withstand temperature swings between ambient to greater than 600°F, be compatible with the process gas or liquid, and withstand possible operational upsets.

Non-regenerative. Non-regenerative units can utilize the "cheapest option." However, with run times usually less than one year before media replacement is required, internals can be damaged during the media unloading, the vessel/internals inspection or the media loading.

All vessels should have a process-flow-inlet distributor and a process-flow-outlet distributor or collector.

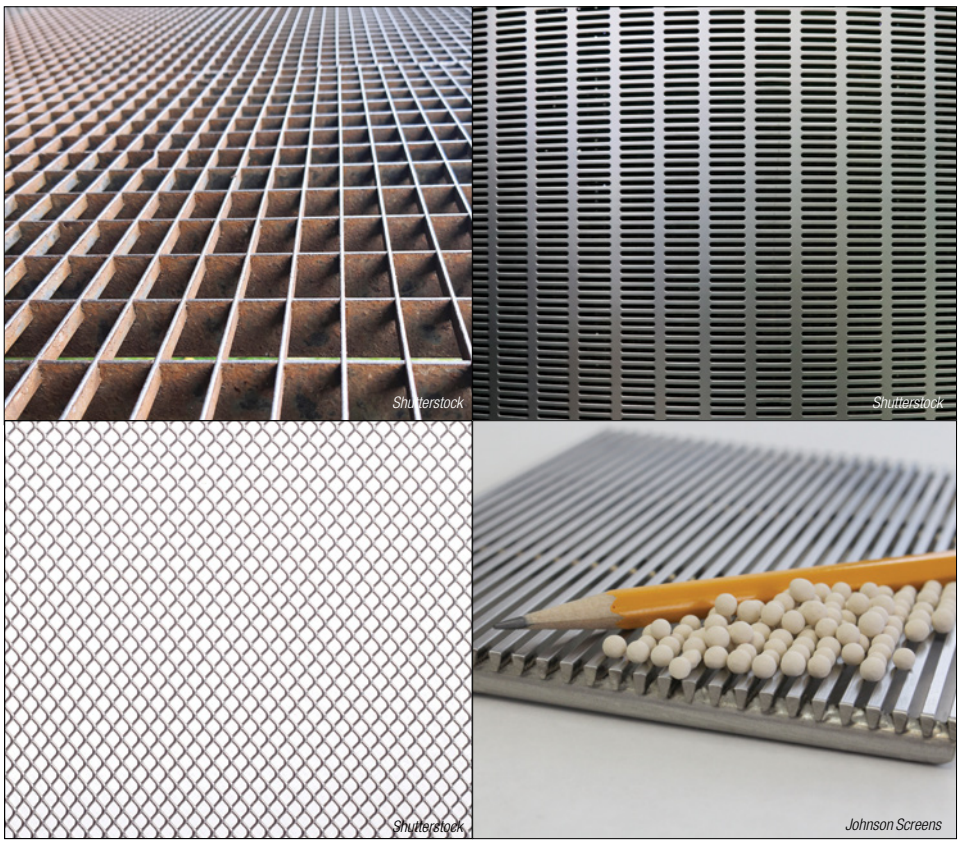

FIGURE 1. Shown here are four typical fabrications options: bar grating (upper left), slotted metal grid (upper right), mesh screen (lower left) and profile wire (lower right)

Depending upon the process application, a support grid(s) will be required. The inlet gas or liquid needs to be evenly distributed to fully utilize the media. In pressure-swing or thermal-swing applications, a process-flow-outlet distributor is required to ensure that the media are properly regenerated. For all down-flow applications an outlet distributor or collector should be installed, even if a support grid is installed. Operational and downstream equipment "nightmares" have resulted when an outlet distributor or collector was not installed.

When designing internals, the vessel piping arrangement and the process application will influence the type, design and material of construction. Piping that enters or exits from the side of the vessel versus piping that enters or exits from the vessel heads will limit the options. Thermal-swing units require support grids to allow expansion and contraction in concert with the vessel. Compatibility with the process gas or liquid will determine the material of construction choices. Flow distribution, end-of-run pressure drop, vessel diameter, media particle size and total weight need to be carefully considered.

Fabrication profiles. As shown in Figure 1, profile wire, slotted metal, mesh screen and bar grating are the typical fabrication options for these vessel internals. They can be used individually or in combination with each other. All internals should be inspected prior to installation and during media replacement. Internals made with mesh screen can tear or become separated so careful inspection is required. Mesh screen repair or replacement can impact the planned schedule.

Distributors. An inlet-flow distributor needs to evenly distribute the gas or liquid before contact with the media. The open area should be greater than 100% of the inlet pipe diameter. Based upon the vessel piping arrangement, it is either welded to the inlet pipe, welded to interior vessel head flange, attached with bolting or sandwich flanges, or attached to interior vessel head bolting tabs. For vessel diameters greater than 10 ft, an enhanced flow distributor should be considered over a standard design. In down-flow processes, the recommended distance between the bottom of the distributor and the media is 3 ft. If the inlet distributor is installed in the bottom of the vessel, it must prevent media leakage and be designed for static and dynamic forces. Fabrication choices are profile wire, slotted metal with profile wire, slotted metal or slotted metal with mesh screen.

An outlet-flow distributor or collector needs to retain the smallest media particle size and prevent media leakage, especially if installed in the bottom vessel head. The open area should be at least 200% of the outlet pipe diameter. In regenerative processes, it must evenly distribute the heating and cooling gas prior to contact with the media. This will ensure that the media is completely regenerated. In down-flow processes, it should be designed for both the static and dynamic forces — even if a support grid is installed above it. Based upon the vessel piping arrangement, it is either welded to the inlet pipe, welded to interior vessel head flange, attached with bolting or sandwich flanges, or attached to interior vessel head bolting tabs. Fabrication choices are profile wire, slotted metal with profile wire, slotted metal, or slotted metal with mesh screen. During media replacement, the mesh screens should be rigorously inspected to ensure no tears or separations have occurred.

Grid supports. Support grids require a vessel ring, vessel beam seats and support beam(s), because the grid lays on top of the vessel ring. Some types of support grids incorporate beams into the grid which also eliminates the need for beam seats. The number of beams required is based upon the vessel diameter. In thermal-swing applications, the support grid needs to be designed for expansion and contraction in coordination with the vessel. The diameter of a support grid should be less than the vessel inside diameter. The void space calculation is performed by support grid suppliers to ensure that the support grid does not fall off the vessel ring or crush itself against the vessel wall. Rope packing is placed in the void space. Compatibility with both expansion and contraction, and the process gas or liquid will impact material-of-construction options. Common materials of construction are 300 or 400 series stainless steel, Inconel, Monel and carbon steel. The individual grid panels need to be sized for easy vessel entry and grid assembly.

A support grid must retain the smallest media particle size. The slot size should be one half the size of the smallest media particle diameter. In down-flow processes, the grid needs to be designed for the static and dynamic force, media weight plus end-of-run pressure drop.

Fabrication choices are profile wire, slotted sheet panels, or multiple mesh screens over bar grating. Multiple (two or three) mesh screens of different slot sizes are required to ensure particle retention and screen strength. During media replacement, the mesh screens should be rigorously inspected to ensure no tears or separations have occurred.

Vessel out of roundness, especially on vessels greater than 15 ft in diameter can present installation and operational headaches. Ideally, the assembly fabrication of the individual grid panels should begin after the "as built" inside diameter and the vessel ring width are measured for each vessel.

Enhanced support-grid designs offer increase operational and reliability benefits. These designs minimize the impact of vessel out of roundness, allow for increased vessel volume of media, and energy savings.

One comment on support grids: the term "Johnson screens" has been, and still is, used interchangeably for a support grid, no matter if it is fabricated from profile wire, slotted metal, or mesh-over-bar grating. Johnson Screens was the company name and is a product brand name for its profile wire product (Johnson Screens Vee-wire). ■

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PVDF Bubble Caps for Distillation Columns

Polymer components in column trays can avoid issues associated with corrosion of metal equipment

Sachin Upadhye, Arkema
Himanshu Mistry, Sangir Plastics

Gujarat Alkalies & Chemicals Ltd. (GACL) — a major chemical producer in Gujarat state in western India — was facing corrosion challenges with its distillation columns. In chemical processing applications, distillation columns are often used to separate and recover solvents and acids. Though these chemicals vary, many of the distillation systems experience corrosion issues if not designed properly for long-term applications. These columns typically utilize metallic components, but the harsh acidic conditions required for this application were not suitable for metals. And while metals can handle high temperatures and have good physical strength, they can be sensitive to rapid attack from acidic conditions and rapid acid concentration changes. In cases where strong acids are present, and when acid concentrations can change within the system, polymer components can be a viable option to prevent corrosion and avoid rusting. This case study describes a project where metal bubble caps in distillation column trays were replaced with bubble caps made from polyvinylidene fluoride (PVDF) resin (Figure 1) in an effort to address corrosion issues with the metal caps in a phosphoric acid plant.

FIGURE 1. Distillation tray bubble caps made from polyvinylidene fluoride (PVDF) resin can be a viable option in cases where metallic components are subject to acid attack

PVDF versus metal

The major purpose of the distillation column is to separate, recover and remove volatile organic compounds (VOCs), solvents and other lighter-than-water substances, which may be present in the flow. For many years, distillation columns have used SS-304 and SS-316 stainless-steel bubble caps, but stainless-steel bubble caps corrode in the presence of some chemicals, such as amines, chlorides and ketones, because the heat-affected zones tend to suffer amine-stress-corrosion cracking or chloride-stress-corrosion cracking, even at lower temperatures. Additionally, stainless-steel bubble caps are more bulky (in weight). Because of this, the distillation column needs to be over-designed and capital costs are high. Another option to avoid corrosion is to use fiber-reinforced polymer (FRP) bubble caps. These are an inexpensive solution, but they need to be frequently replaced due to delamination, which leads to embrittlement and failure.

The decision to switch from a metallic construction to PVDF was driven by the use of phosphoric acid in the plants. Previous distillation systems using metal components had experienced corrosion, and resolving the issue became essential for GACL to keep the plant running. When GACL sought to resolve corrosion-related issues in the distillation columns of their food-grade phosphoric acid plant, project consultant Worley India recommended they replace conventional metal bubble caps in column trays with bubble caps made from Kynar PVDF. Sangir Plastics Pvt. Ltd. is one of the major users of Kynar PVDF raw material, and is also a leading producer of customized thermoplastic products. They were able to successfully manufacture bubble caps using Kynar PVDF resins. The fabricator to which the products were supplied was Dolf Industries Pvt. Ltd. Vadodara Gujarat.

FIGURE 2. PVDF components can withstand a wide range of pH conditions

Kynar PVDF is known to have resistance to a wide range of solvents and acids. Kynar PVDF homopolymers are known to withstand pH values of <1 to 12 while Kynar Flex PVDF copolymers handle a wider pH range, from <<1 to 13.5. Operating parameters dictate the use of engineered thermoplastics, such as PVDF, and based on the service conditions and the chemicals characteristics, Kynar PVDF was selected for this project as the most suitable and compatible material of construction. GACL acheived cost savings due to the lighter weight of the PVDF materials, and also was able to optimize the critical process conditions by using lower temperatures and pressures.

Producing PVDF bubble caps

The Kynar PVDF bubble caps were manufactured from Kynar raw material supplied by Arkema. The manufacturing process involved extrusion, injection molding and fabrication.

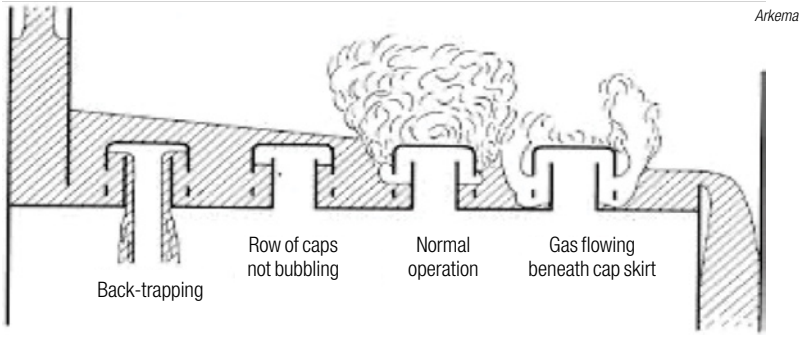

FIGURE 3. In bubble cap trays, vapor rising through the column is turned downward to bubble through the liquid surrounding the cap

The manufacturing process also involved a high-degree of precision, exactness, finish and working within very close dimensional tolerances. Distillation columns require such precision to uniformly dissolve fumes and liquids. Not only did Arkema provide expertise in manufacturing the Kynar PVDF bubble cap, but they also met such stringent requirements and gave extensive reccommendations on the fabrication processes to ensure the caps met the high level of quality requirements for the project. This project was the first time that such a product has been manufactured and supplied by injection molding, fabrication, and butt fusion to produce a highly sophisticated product. A large number of bubble caps were supplied successfully under stringent quality control conditions.

High-value polymers are lightweight and can be easily fabricated with cutting tools and heat welding. This eases both the process and costs of installation.

PVDF in the column

The Kynar PVDF bubble caps are part of bubble-cap-tray assemblies (Figure 3) used in a distillation column for low-temperature and low-pressure (*P/T*) applications. In bubble cap trays, vapor flowing up through the tower contacts the liquid by passing through the bubble caps. Each bubble-cap assembly consists of a riser and a cap. The vapor rising through the column passes up through the riser in the tray floor and then is turned downward to bubble into the liquid surrounding the cap. Due to their design, bubble cap trays cannot weep or leak distilled liquid. This design is suitable for yield in lower-pressure and lower-temperature conditions. However, the bubble cap needs to be designed and manufactured with extreme care to ensure that each bubble cap operates at the same efficiency factor. Thus, bubble caps are required to be exactly identical, with the same dimensional tolerances.

Kynar PVDF bubble caps are used in distillation columns operating at low pressures and temperatures, as they are a good alternative to stainless-steel or FRP bubble caps. PVDF bubble caps offer extensive operational life because the product can withstand temperatures up to 130°C (266°F) and are inert to the majority of the solvents and catalysts found in distillation columns. ■

Edited by Scott Jenkins

Authors

Sachin Upadhye is a business manager in the High Performance Polymers Unit at Arkema in India (Email: sachin.upadhye@arkema.com). He holds post-graduate degrees in both chemistry and paint technology. Upadhye has 29 years of experience in industrial applications and material selection.

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Avoiding Mistakes When Emptying Spill Pallets

Following these guidelines can help workers to take the proper precautions to minimize the risk of leakage from spill pallets

Steve Eyer
Denios

Container liquid leaks can occur at any time, even when all precautions have been taken and containers are stored on a spill pallet (Figure 1). In these situations, serious mistakes can happen when emptying the spill pallets. Prevention is the best policy — but in case leaks or spills do occur, facilities need to be prepared for them. This article provides some guidelines that facilities can take to avoid making mistakes when emptying their spill pallets.

Act timely

In the event of a leak, facilities must take immediate action for the health and safety of their employees. A quick response requires timely identification of leaks and spills. Checking all liquid-storage containers regularly is time consuming. An early-warning system for leaks, for instance, alerts users when a leak or spill is identified. Such systems may produce a loud audible tone (beeping) and visual indication (such as flashing lights) and continue for at least a 24-h duration, alerting users of an ongoing liquid spill or leak. The continued warning allows these automatic tools to be employed in areas of the facility where few employees may be present.

After a leak or spill has been identified, employees must quickly assess the risk posed by the leak, identify the spilled liquid and the amount spilled. Depending on the risk assessment, it may be necessary or advisable to halt production and evacuate the area, in addition to informing auxiliary personnel.

Wear PPE

Emptying a spill pallet should be done in the same way as cleaning up any other leaks — safely. One of the first steps is to use personal protective equipment (PPE), including eye and hand protection and safety shoes, at a minimum. Other equipment, such as respiratory or body protection, could be required, depending on the spilled substance and quantity. Consulting the site's operating instruction manual or safety data sheets will most likely denote exactly what type of PPE is recommended.

FIGURE 1. Spill pallets are designed to minimize spills and leakage from storage containers, but loss of containment can still occur in certain circumstances

Transport and remove

Transporting or dumping liquids poses a significant risk of secondary leaks. Therefore, moving and dumping spilled liquid should be done cautiously. Never move with a lift truck or by yourself. Even if several people attempt to lift the pallet together, the risks of contamination to the environment and employee safety are too high. Instead, personnel should follow standard safety procedures and drain the liquid with a pump or liquid aspirator.

FIGURE 2. There are a wide variety of absorbent materials designed for spill cleanup. It is imperative to ensure that the absorbent is compatible with the materials that have been spilled

Drain the spilled liquid

Draining spilled liquid using a pump or aspirator is another instance where secondary leakage can be created. Even if protective gloves are worn, large-scale contact with the hazardous material may arise. Do not take unnecessary risks. If the amount of fluid is small, an absorbent may also be sufficient to clean up the spill. Remove the liquid as completely as possible from the drip tray and check to see if there is any residue. This can be taken up with an absorbent as well. Then, the drip tray should be thoroughly decontaminated and cleaned.

Check tool compatibility

The same cleanup method, such as a specific absorbent, is not suitable for all chemicals (Figure 2). Users must ensure that the cleanup product is suitable for the specific spilled substance. Also, it is crucial that operators diligently check that equipment is compatible before using it with a chemical cleanup method. Keep the appropriate products easily accessible so that the right tool will always be readily available in case any problems occur (Figure 3).

FIGURE 3. All tools used for spill cleanup must be compatible for use with the liquid that has been spilled, the storage equipment itself and any other tools used in the cleanup

Use the right cleaning agent

Depending on what liquid has leaked, water or a suitable cleaner can be used to decontaminate the sump. However, avoid mechanical cleaning and do not use anything that could damage the sump's material, such as abrasives. Otherwise, the functionality of the spill pallet cannot be guaranteed.

Check the sump

After a spill, operators should thoroughly examine the substances that are being stored on the sump. If incompatible operating materials are placed on the bottom of the previously stored product, undesirable interactions may occur. Always check that new substances are compatible for overall team safety. Being prepared to deal with leaks comes down to doing the appropriate homework beforehand and ensuring that all employees have what they need to safely deal with the situation. It is wise to practice various spill or leak scenarios, especially when dealing with dangerous or hazardous materials. Ensuring that employees know what to do in the case of a leak or spill, including where to find the tools they need, will help ensure a successful outcome. Leaks are not totally preventable, but unsafe spill cleanups are. ■

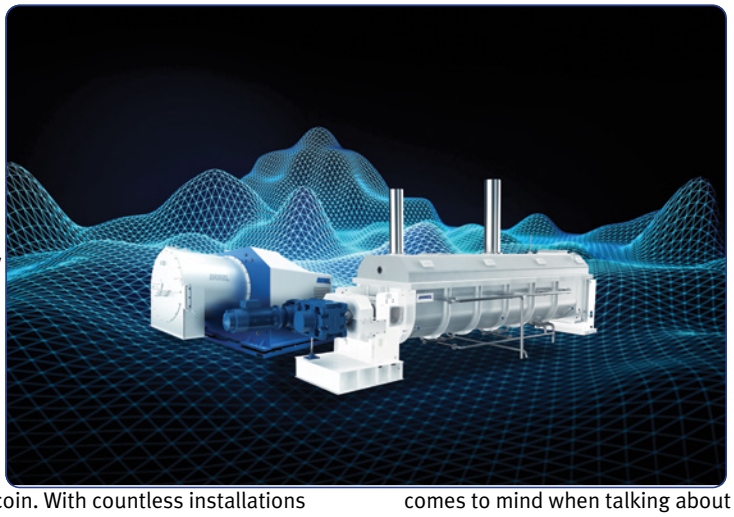
Edited by Mary Page Bailey

All images courtesy of Denios

Author

Steve Eyer is an engineered systems sales manager at the Denios U.S. office (1152 Industrial Blvd, Louisville, KY 40219; Phone: 1-800-216-7776; Email: seyer@denios-us.com). He has over 25 years of experience within the safety industry with a focus on design and engineering of flammable combustible products. Eyer has contributed to industry regulations and given influence for engineered judgments to third-party insurers. He is also a three-time patent recipient. He has a degree in mechanical engineering from Vincennes University in Indiana and is currently pursuing his M.S. in technology from Eastern Illinois University.

Separation and automation boost chemical production



For all applications in the chemical industry, there is no room for compromise when it comes to safety, product purity, and non-stop performance. This is why companies like international technology group **ANDRITZ** are determined to constantly work on their product portfolio and develop new solutions with their customers – all while improving proven machines and processes. But what lies behind these promises?

Extensive process knowledge is only one side of the coin. With countless installations worldwide, ANDRITZ has a proven track record of achieving excellent results while guaranteeing minimum downtime. The broad dewatering and drying portfolio includes pusher and decanter centrifuges as well as paddle-, plate-, helix-, and fluid bed dryers. With this large portfolio, the company can not only provide solutions for the vast array of manufacturing processes in the field of specialty chemicals (such as sustainable nutrition, advanced transportation, and much more), but also offer mechanical separation and drying in a single package.

If you always do what you've always done, you'll always get what you've always got

This famous quote by Henry Ford shows why developing the next generation of dewatering and drying solutions is necessary to enable continuous efficiency and quality improvements. One option for achieving said improvement: ANDRITZ's pilot plants around the world, where the company designs and tests dewatering and drying solutions as well as production processes in collaboration with its customers. With this approach, the wealth of expertise is always expanding. Another thing that comes to mind when talking about continuous learning is artificial intelligence. And this is where Metris addIQ control systems come in. They are part of Metris, the ANDRITZ brand for digital solutions. These innovative automation solutions cover everything from basic automated movement up to a point where the machine can recognize changes and imbalances within the process and help operators to optimize accordingly. Predictive maintenance, process monitoring, troubleshooting, and long-term trending are only some of the benefits that come with digitalization. Extensive experience paired with innovation and digitalization to deliver improvements precisely where they are needed – this is the key to Industry 4.0.

www.andritz.com/group-en

Reduce the Operating Cost of Your Plant with IIoT

Using MATLAB and Simulink, acquire and analyze data from your process equipment and build predictive models

According to the U.S. Energy Information Administration, U.S. chemical industry companies consumed over 7 trillion BTUs of energy in 2018, the most of any manufacturing industry. The most energy-intensive chemical manufacturing processes include ethylene, nitrogenous fertilizer, chlorine, and caustic soda production. The energy consumption of these processes, as well as plants' HVAC needs and equipment maintenance, contributes to the operating costs of facilities.

Chemical engineering organizations have started building and using industrial Internet of Things (IIoT) solutions to address these challenges and minimize operational costs. Successful IIoT programs enable engineers to build models that can predict energy loads, monitor emissions, create digital twins of their assets, predict assets' maintenance needs, and develop process control and optimization strategies. Developing these programs starts with acquiring process data, such as temperature, pressure, and flow rate, from chemical process equipment, arrays of network-enabled sensors, connected instrumentation, or databases. Data volume and sharing needs dictate how and where data is stored—locally or in the cloud. Engineers preprocess the raw data, develop visualizations and models, and create apps or dashboards to uncover insights and potential actions.

Many chemical engineers use **MATLAB®** and Simulink® software to build IIoT solutions that minimize operational costs. A critical recent development is the use of digital twins—virtual representations of the operating devices and processes created in Simulink—to optimize plant, device, and process operations.

Uncovering actionable insights from large data sets can take time and effort. Machine learning or deep learning models can be developed depending on the information required to alleviate resource constraints. Engineers in the chemical industry use MATLAB to quickly build data-driven models that predict the energy demand of chemical processes, emissions, or the remaining useful life (RUL) of critical equipment such as heat exchangers, pumps, and compressors. These models can help companies minimize the cost and environmental impact of their operations.

MathWorks equips engineers with tools to develop end-to-end IIoT solutions with built-in support to acquire sensor data; develop their first-principles, data-driven, or hybrid models; develop control and optimization algorithms; and deploy them on hardware or create actionable apps or dashboards.

www.mathworks.com/solutions/chemicals-and-petrochemicals

New Monitor/Controllers Feature 7 Parameters in 1

Myron L Company multi-parameter water quality monitor/controllers are easy to install, easy to use, and do the job of multiple monitors and controllers.

900 Series Multi-Parameter Monitor/Controllers include everything required to simplify water quality management across industrial applications in a single user-intuitive instrument. Simultaneously monitor and control critical water quality parameters through multiple inputs/outputs with the legendary accuracy and reliability the **Myron L** Company has come to be known for. 900 Series Monitor/Controllers feature a simple-to-use LCD touchscreen Graphical User Interface along with pluggable terminal blocks for quick and easy equipment installation and configuration.

Monitor 7 critical water quality parameters simultaneously from easily configured inputs: 2 Conductivity/Resistivity/TDS/Salinity; 1 pre-amplified pH/ORP; 1 BNC pH/ORP; 1 0-20/4-20 mA; 1 RTD Temperature; and 1 Flow/Pulse. % Rejection is available as a derived value. Conductivity/TDS measurements feature the ability to select from one of three preprogrammed solution modes, KCl, NaCl, or Myron L's own 442 Natural Water Standard, or to program a User solution mode based on a known solution. Temperature compensation is automatic to 25°C or can be disabled by the user as required. The pH/ORP input channel is designed for use with Myron L pre-amplified pH and ORP sensors. These sensors contain precision circuitry that increases accuracy and permits application of the sensors over greater distances. The 0-20/4-20 mA input allows user-defined 0 to full scale values and units of measure for a wide array of sensor types. Electronic or wet calibrations are easy to perform.

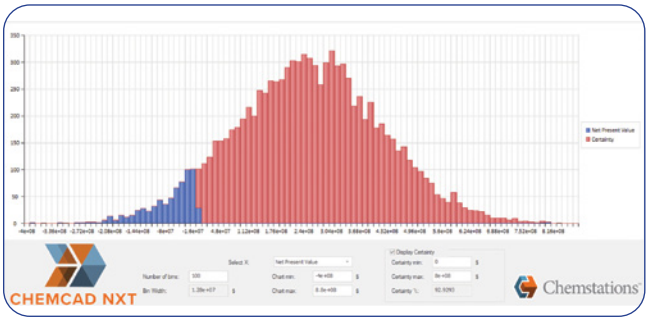
Outputs include up to 3 relays; 2 remote alarms; 1 0-20/4-20 mA; 1 0-5/0-10 VDC; and 1 RS-485 ASCII Serial Output. Relays output to any user-supplied control equipment requiring up to 250V each and can trigger on any input parameter. The 0-20/4-20 mA output can transmit a signal for any input parameter. 0-5/0-10 VDC can be scaled to optimize resolution and can output to a recorder, PLC, SCADA system, etc. 0-1 VDC is possible with optional resistor. Hysteresis values can be specified by the user or automatically set by the 900 Series to prevent chatter.

The flow switch input can disable all relay outputs when triggered by loss of flow. User adjustable cell constant (Conductivity/Resistivity/TDS/Salinity) and sensor cable length (Conductivity/Resistivity/TDS/Salinity, pH and RTD) increase accuracy. Administrator and Operator password protection levels prevent unwanted tampering. The brightly colored red, yellow, and/or blue LCD background instantly alerts the user to the solution status. A DIN Size Chassis makes it easy to mount.

Myron L also backs these instruments up with live dedicated technical support that assures installation and operation success.

www.myronl.com

Leverage Rigorous Simulations in Monte Carlo Analyses



Traditional process simulation, whether steady-state, batch, or dynamic, can be used to analyze "what-if" scenarios. Processes are often varied manually or with a sensitivity analysis, an approach involving several if not tens of simulations. Optimizers can be used to minimize or maximize an objective function and may run tens, hundreds, or thousands of simulations.

A more common tool used when certain process variables have inherent uncertainties is a Monte Carlo analysis, wherein thousands, if not tens of thousands, of simulations must be run. A user defines the uncertainties of each independent variable, and the output is the distribution of the resultant objective, usually presented in a histogram. Using a statistical approach like Monte Carlo not only drives insight into process behavior but, when integrated with a cost model, can guide the process design and uncover relationships that are beyond purely technical considerations.

Until recently, rigorous techno-economic simulation would not have been considered useful in such a calculation because of the time and resources required. The individual simulation calculations were slow, and a farm of simulator licenses and computer systems would have been necessary to achieve usable results in a reasonable amount of time. Today, however, a single CPU with one software license can perform object-oriented, parallelizable calculations to deliver results at exponentially higher speeds than in the past.

As an illustration of the concept, consider a carbon capture process, modeled in **CHEMCAD**, wherein the carbon dioxide content of raw gas can vary (mean = 4.85% and standard deviation = .08%). The pertinent question is, "What is the certainty that our facility will have a positive operating net present value (NPV)?" The CO_2 content is randomly varied in 10,000 simulations, which takes approximately two minutes on a four-core laptop. The resultant plot shows a 93% certainty that NPV will be positive given the process feed uncertainty.

The setup, calculations, and reporting are all done with a single tool in a single interface, providing maximum flexibility and usability for process engineers solving real challenges. To learn more, please visit us at:

www.chemstations.com/CE

Unleashing IIoT Potential: Trillium Flow Technologies Redefines Valve Performance and Maintenance

Trillium Flow Technologies' new smart valve technology harnesses big data and capitalizes on the digital transformation efforts seen in industrial markets as IIOT gains traction. Meticulously designed to offer comprehensive care for your plant's existing systems, our cutting-edge solution delivers real-time monitoring capabilities, empowering you to undertake planned preventive maintenance, reduce downtime, and significantly enhance productivity.

Our technology encompasses a simple bolt-on approach, upgrading the existing valve by collecting operational data using an interactive dashboard. The technology provides secure connectivity and real-time data analysis. Process data is gathered from Trillium-installed sensors or existing infrastructure, with wireless pressure transducers installed on upstream and downstream pipework. The predictive algorithm then processes live pressure readings and flow meter outputs to map valve performance.

Harnessing the power of control valves with embedded sensors, our system utilizes the innovative SMART algorithm to predict performance degradation. This enables you to schedule repair or replacement in a controlled manner, effectively avoiding the need for ad-hoc maintenance work and costly emergency valve repairs.

User-friendly software eliminates the need to review extensive diagnostic data and offers clear guidance on failure types and part replacement planning, enabling efficient resource deployment and just-in-time spare part delivery. An interactive dashboard provides a comprehensive overview of equipment performance, with the flexibility to delve deeper into areas of concern – while clear visuals and alarms offer crucial information for decision-making on underperforming assets.

Our scalable gateway infrastructure allows for remote real-time monitoring of hundreds of assets worldwide from a single location. The system can function as a standalone cloud station or seamlessly integrate into your existing infrastructure, ensuring secure data transfer through a cloud environment and protecting equipment performance data during local and remote access. Third-party hardware interfaces can be created locally or in the cloud to gather process information to support the algorithm.

By leveraging Trillium's remote monitoring capabilities, you can eliminate the extra cost of on-site valve expertise. The system maintains direct contact with the Trillium services division, providing rapid response instructions for detected failures and ensuring swift problem resolution. In addition, our team is always available to conduct thorough analyses and recommend the best solutions to resolve issues.

Experience the plant maintenance and productivity revolution with Trillium's advanced digital transformation technology, expertly crafted for the modern industrial world. Learn more at

www.trilliumflow.com/smart

Unleashing the digital potential of valve actuators

Electric actuator manufacturer AUMA has launched **CORALINK**, its new digital ecosystem. CORALINK supports plant operators across all phases of the plant's lifecycle, from commissioning and predictive maintenance to active life cycle management of their AUMA actuators.

Plant operators can ensure sustained plant availability and benefit from simple and efficient processes in everyday operation. At the heart of CORALINK is the ability to evaluate the extensive operating data that AUMA actuators record automatically in their role as intelligent field devices. The data can easily be read from each AUMA actuator, including via a smartphone.

A new feature is a detailed action plan with concrete recommendations for action, which is accessible through just a few clicks. These recommendations are based on the combined expertise of AUMA service experts and decades of field experience. Plant operators can thus identify maintenance requirements at an early stage and take corrective measures in good time.

CORALINK also provides easy online access to documentation, spare parts ordering and AUMA service experts.

CORALINK is scalable and can be used to check the condition of individual critical actuators, to monitor all the actuators on a plant, or to implement IIoT solutions.

AUMA provides CORALINK free of charge in a very comprehensive basic version.

For more information visit **coralink.auma.com**

CORALINK, AUMA's digital ecosystem, helps plant operators ensure sustained plant availability while benefitting from simple and efficient processes around AUMA actuators.

i.safe MOBILE/Senseven present Valve Sense

First smart and mobile valve inspection system for ATEX zones

i.safe MOBILE, in cooperation with its technology and strategy partner Senseven, has launched a new development for hazardous areas: Valve Sense is a mobile, smart inspection system for valve monitoring, which has now been introduced for ATEX environments. The new system enables the inspection of critical valves in hazardous industrial environments and allows companies to improve the safety, reliability and efficiency of maintenance processes-easy to handle and complying with the strictest safety standards. Valve Sense uses software and artificial intelligence to detect potential leaks and safety risks in industrial valves. Especially in the chemical, pharmaceutical, petroleum processing and other demanding industries, malfunctions in valves pose a great danger and can lead to considerable consequential damage in plants.

The product introduction makes the two companies the first on the market to apply today's digital capabilities to an inspection system. The user-friendly kit connects acoustic emission sensors to i.safe MOBILE's 5G smartphone IS540.x, transforming it into a smart inspection system for leak detection in valves. The software guides the user through the inspection process and algorithms and artificial intelligence help interpret the data. The Senseven app supports the user during the inspection process, automatically interprets sensor signals and provides immediate results on site. All data is automatically stored in a back office for further analysis and reporting. This simple solution makes it possible to inspect industrial assets without training or expertise. Companies can regularly check their plants without interrupting the production process, detect potential hazards and damage at an early stage and react promptly. **www.i.safe-mobile.com**

Say goodbye to outdated maintenance schedules with Busch's digital technology

Avoid unnecessary costs

While preventative maintenance is a wise step, it can add unnecessary costs if equipment is already operating well. Corrective maintenance can be even more expensive, take more time and require more components. Don't forget the cost of downtime when equipment fails.

With predictive analytics, detect real-time machine data patterns that might cause problems. By analyzing data, predict weeks in advance which machine parts may fail. This makes it easy for maintenance teams to plan repairs and order parts beforehand, minimizing downtime and reducing the chances of recurring problems. **Innovative IoT technology saves time and money by guiding maintenance decisions.**

Busch offers two types of digital technologies to transform vacuum pump maintenance and efficiency. First is the Busch PLUS intelligent, fully connected vacuum pump. It combines proven Busch reliability with monitoring features ready for Industry 4.0. Data is accessed directly on the built-in display or transferred via a Modbus TCP/IP client/server protocol.

The second is the OTTO vacuum pump condition monitoring tool that identifies the optimal time for pump maintenance. OTTO is a standalone monitoring tool that transmits via GSM to a user-friendly web app to enable convenient monitoring and control.

Both technologies interpret the vacuum pump and process conditions and signal when (and what) service is required based on the actual pump condition.

www.buschusa.com

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Classified Index June 2023

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June 2023; VOL. 130; NO. 6

Economic Indicators

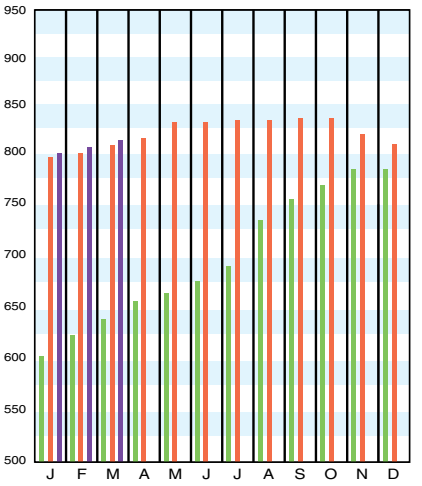
2021 2022 2023

Download the CEPCI two weeks sooner at www.chemengonline.com/pci

CHEMICAL ENGINEERING PLANT COST INDEX (CEPCI)

(1957–59 = 100)	Mar. '23 Prelim.	Feb. '23 Final	Mar '22 Final
CE Index	799.5	798.0	803.6
Equipment	1,009.0	1,008.2	1,017.9
Heat exchangers & tanks	821.1	820.2	859.0
Process machinery	1,032.6	1,031.4	1,016.8
Pipe, valves & fittings	1,403.9	1,403.4	1,452.8
Process instruments	566.6	565.1	566.1
Pumps & compressors	1,391.9	1,391.5	1,242.3
Electrical equipment	797.0	794.7	743.2
Structural supports & misc.	1,119.0	1,120.8	1,128.2
Construction labor	361.8	358.6	346.1
Buildings	806.0	801.5	831.3
Engineering & supervision	313.0	311.3	312.3

Annual Index:
2015 = 556.8
2016 = 541.7
2017 = 567.5
2018 = 603.1
2019 = 607.5
2020 = 596.2
2021 = 708.8
2022 = 816.0

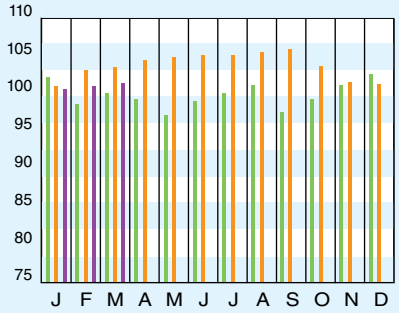


Starting in April 2007, several data series for labor and compressors were converted to accommodate series IDs discontinued by the U.S. Bureau of Labor Statistics (BLS). Starting in March 2018, the data series for chemical industry special machinery was replaced because the series was discontinued by BLS (see *Chem. Eng.*, April 2018, p. 76–77.)

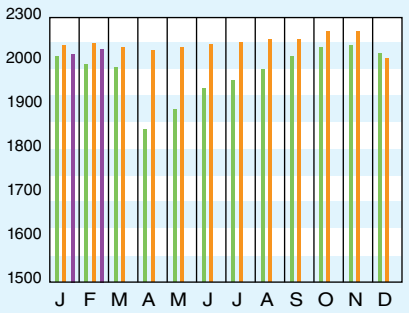
CURRENT BUSINESS INDICATORS

	LATEST	PREVIOUS	YEAR AGO
CPI output index (2017 = 100)	Mar. '23 = 100.0	Feb. '23 = 100.3	Jan. '23 = 99.3	Mar. '22 = 101.3
CPI value of output, $ billions	Feb. '23 = 2,076.7	Jan. '23 = 2,096.1	Dec. '22 = 2,064.5	Feb. '22 = 2,004.7
CPI operating rate, %	Mar. '23 = 79.9	Feb. '23 = 80.2	Jan. '23 = 79.5	Mar. '22 = 82.0
Producer prices, industrial chemicals (1982 = 100)	Mar. '23 = 328.0	Feb. '23 = 326.7	Jan. '23 = 333.4	Mar. '22 = 355.0
Industrial Production in Manufacturing (2017 =100)*	Mar. '23 = 99.5	Feb. '23 = 100.0	Jan. '23 = 99.4	Mar. '22 = 100.6
Hourly earnings index, chemical & allied products (1992 = 100)	Feb. '23 = 209.6	Jan. '23 = 211.6	Dec. '22 = 208.8	Feb. '22 = 197.5
Productivity index, chemicals & allied products (1992 = 100)	Mar. '23 = 92.2	Feb. '23 = 92.4	Jan. '23 = 90.6	Mar. '22 = 93.8

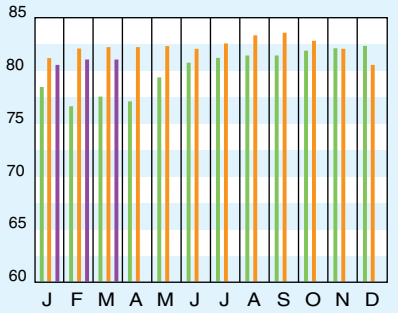
CPI OUTPUT INDEX (2017 = 100)†



CPI OUTPUT VALUE ($ BILLIONS)



CPI OPERATING RATE (%)



*Due to discontinuance, the Index of Industrial Activity has been replaced by the Industrial Production in Manufacturing index from the U.S. Federal Reserve Board.
†For the current month's CPI output index values, the base year was changed from 2012 to 2017
Current business indicators provided by Global Insight, Inc., Lexington, Mass.

CURRENT TRENDS

The preliminary value for the *CE* Plant Cost Index (CEPCI; top) for March 2023 (most recent available) is slightly higher than the February values. All four subindices (Equipment, Buildings, Construction Labor, and Engineering & Supervision) rose slightly from the previous month. The final February CEPCI value was downwardly revised from its preliminary value, due in part to new Bureau of Labor Statistics data that were published for two producer price index (PPI) series IDs that had remained unpublished, and therefore unchanged, for several months prior to this one. The current CEPCI value now sits at 0.5% lower than the corresponding value from one year before. The CPI Output Index for March was down slightly.

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